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Hasegawa et al.

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(54) **ELECTROMAGNETIC RELAY**

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(73) Assignee: **Fujitsu Component Limited**, Tokyo (JP)

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(22) Filed: **Apr. 24, 2013**

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(51) **Int. Cl.**

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H01H 50/02	(2006.01)
H01H 50/04	(2006.01)
H01H 50/44	(2006.01)
H01H 50/14	(2006.01)

(52) **U.S. Cl.**

CPC ***H01H 50/021*** (2013.01); ***H01H 50/04*** (2013.01); *H01H 50/443* (2013.01); *H01H 50/14* (2013.01)

USPC **335/78**; 335/83

(58) **Field of Classification Search**

CPC H01H 50/02; H01H 50/021; H01H 50/04; H01H 50/14; H01H 50/443

USPC 335/78–86

See application file for complete search history.

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(57) **ABSTRACT**

An electromagnetic relay includes: a main body including: a first cover; an electromagnet having a first terminal extending toward the outside from a bottom surface of the first cover; and a contact portion that opens and closes according to a magnetic attractive force of the electromagnet, and has a second terminal extending toward the outside from the bottom surface of the first cover; a cable line drawn out to the outside of the electromagnetic relay; and a printed circuit board that fixes the cable line to at least one of the first terminal and the second terminal by dip soldering, and electrically connects the cable line to the at least one of the first terminal and the second terminal.

14 Claims, 14 Drawing Sheets

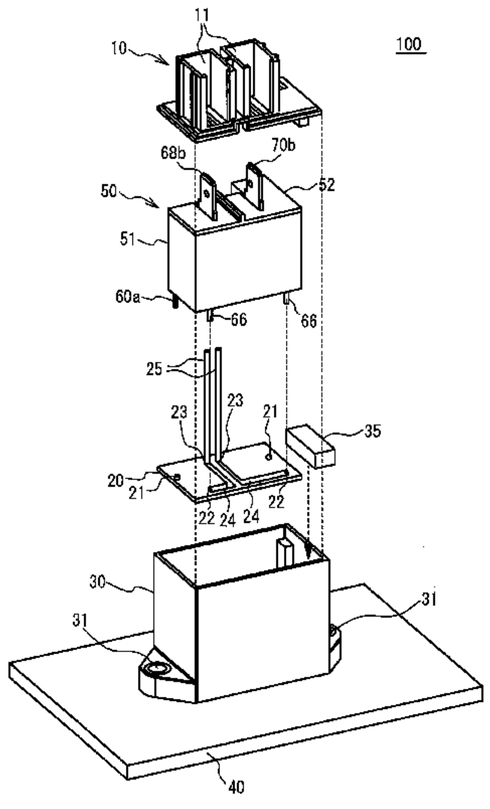


FIG. 1A

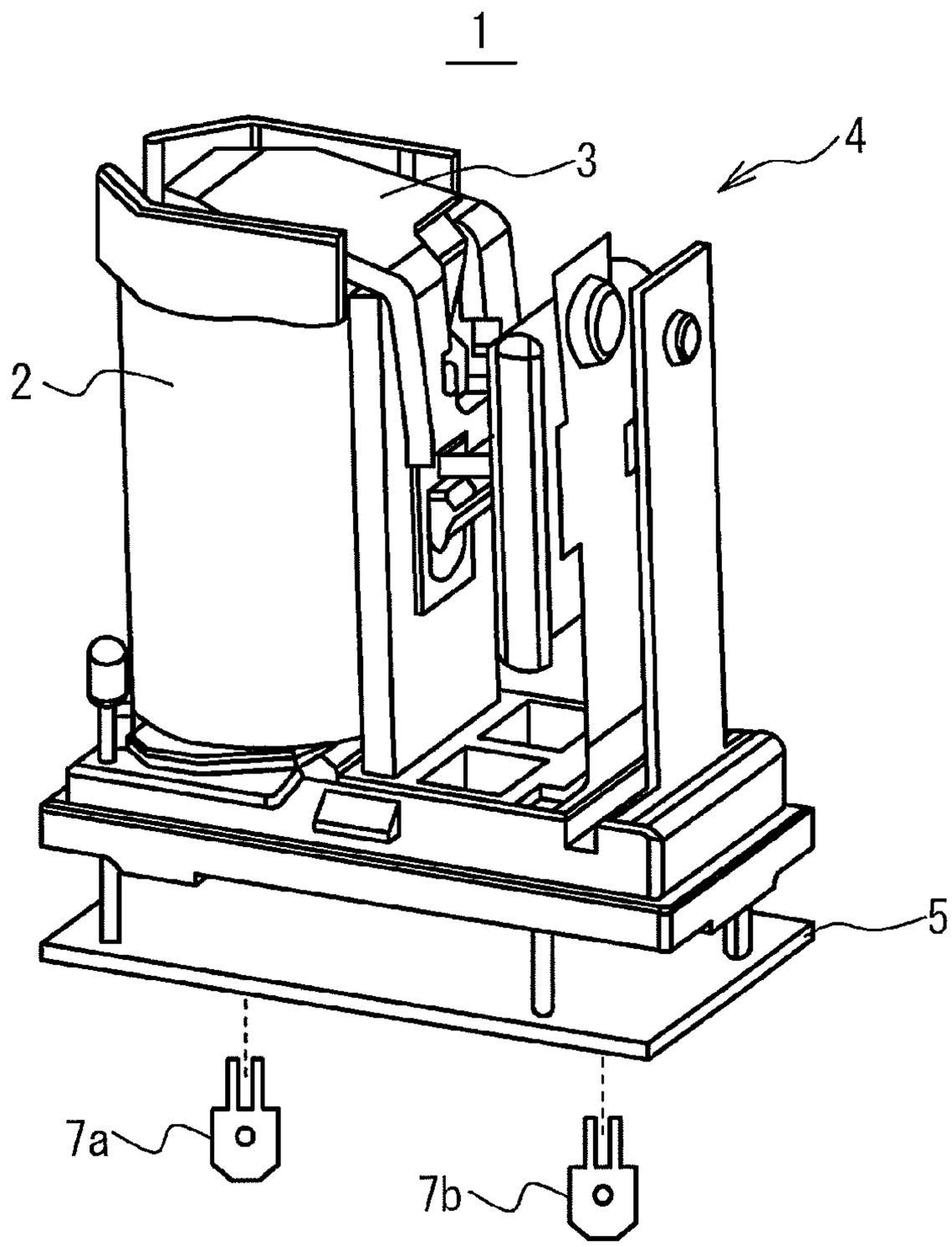


FIG. 1B

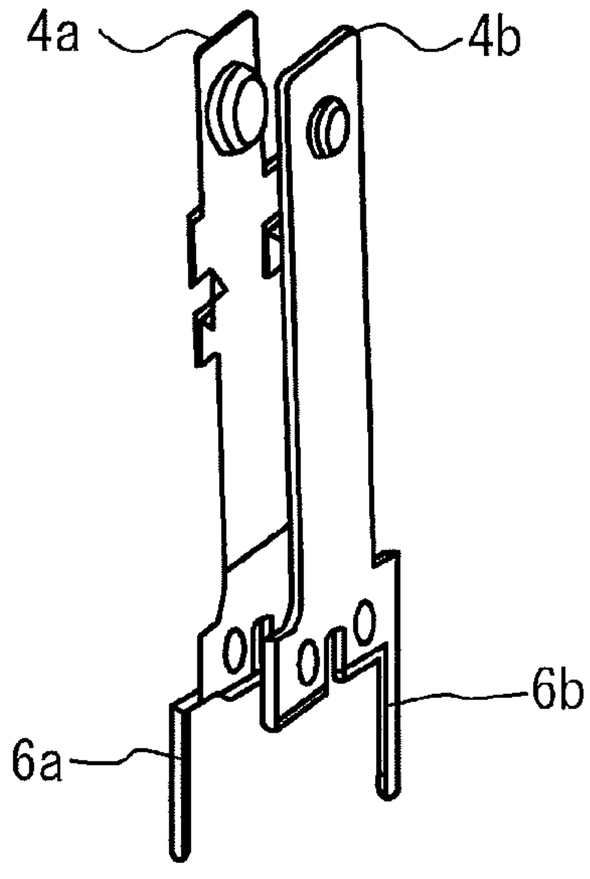
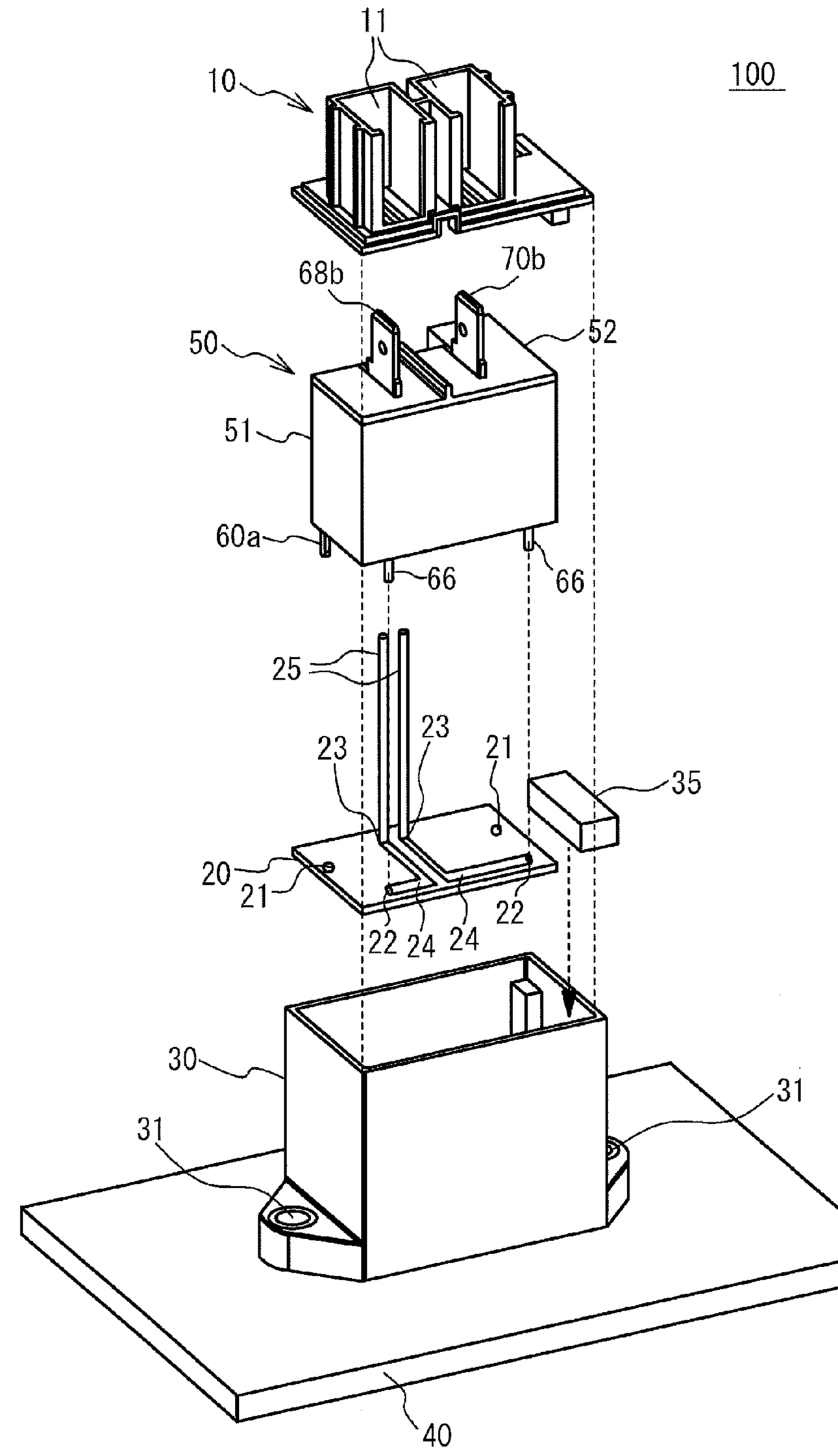


FIG. 2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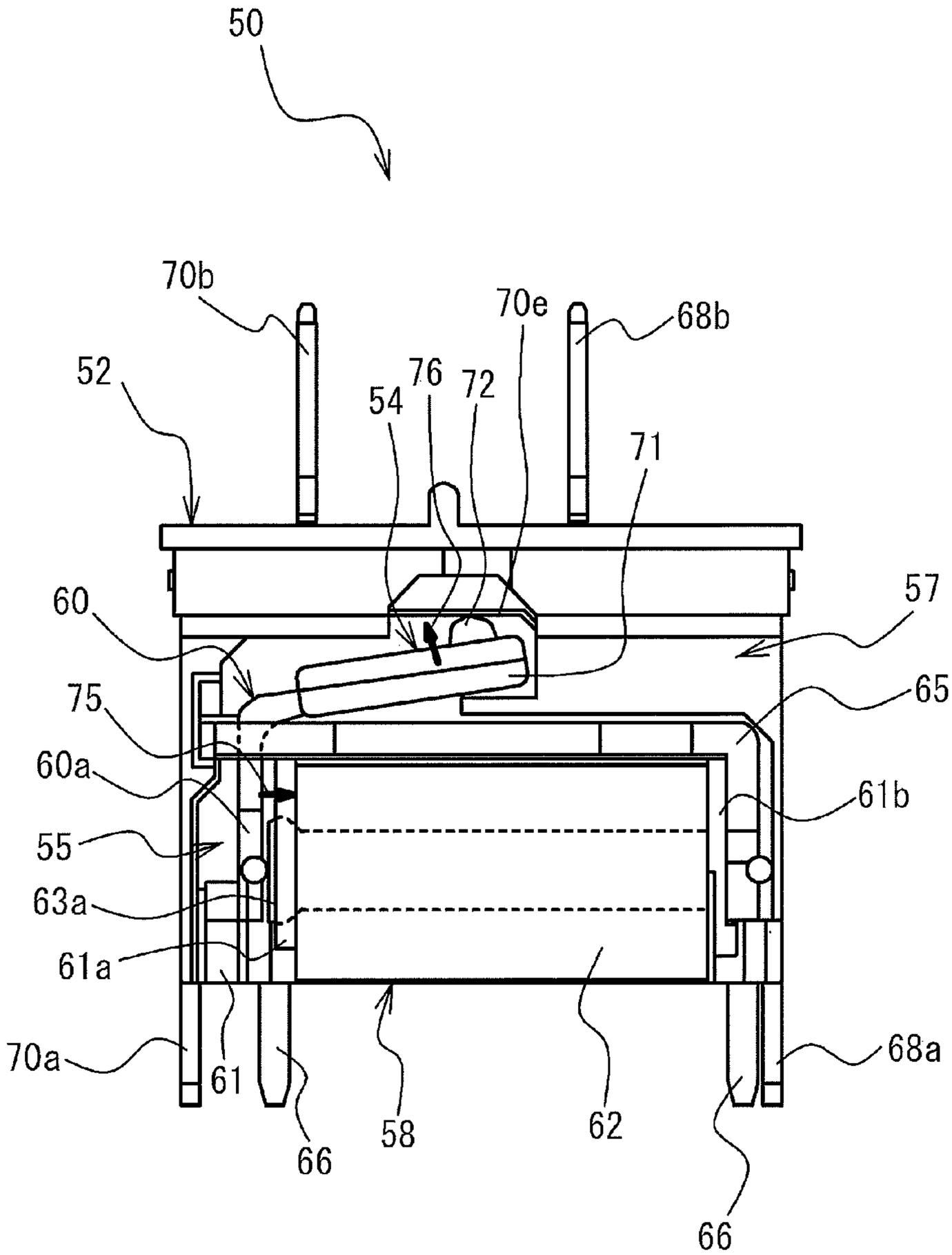
10
100
68b
70b
50
52
51
60a
66
66
25
23
23
21
35
20
21
22
22
24
24
30
31
31
40

FIG. 3


50
70b
70e
68b
52
54
76
72
71
60
57
75
65
60a
61b
55
63a
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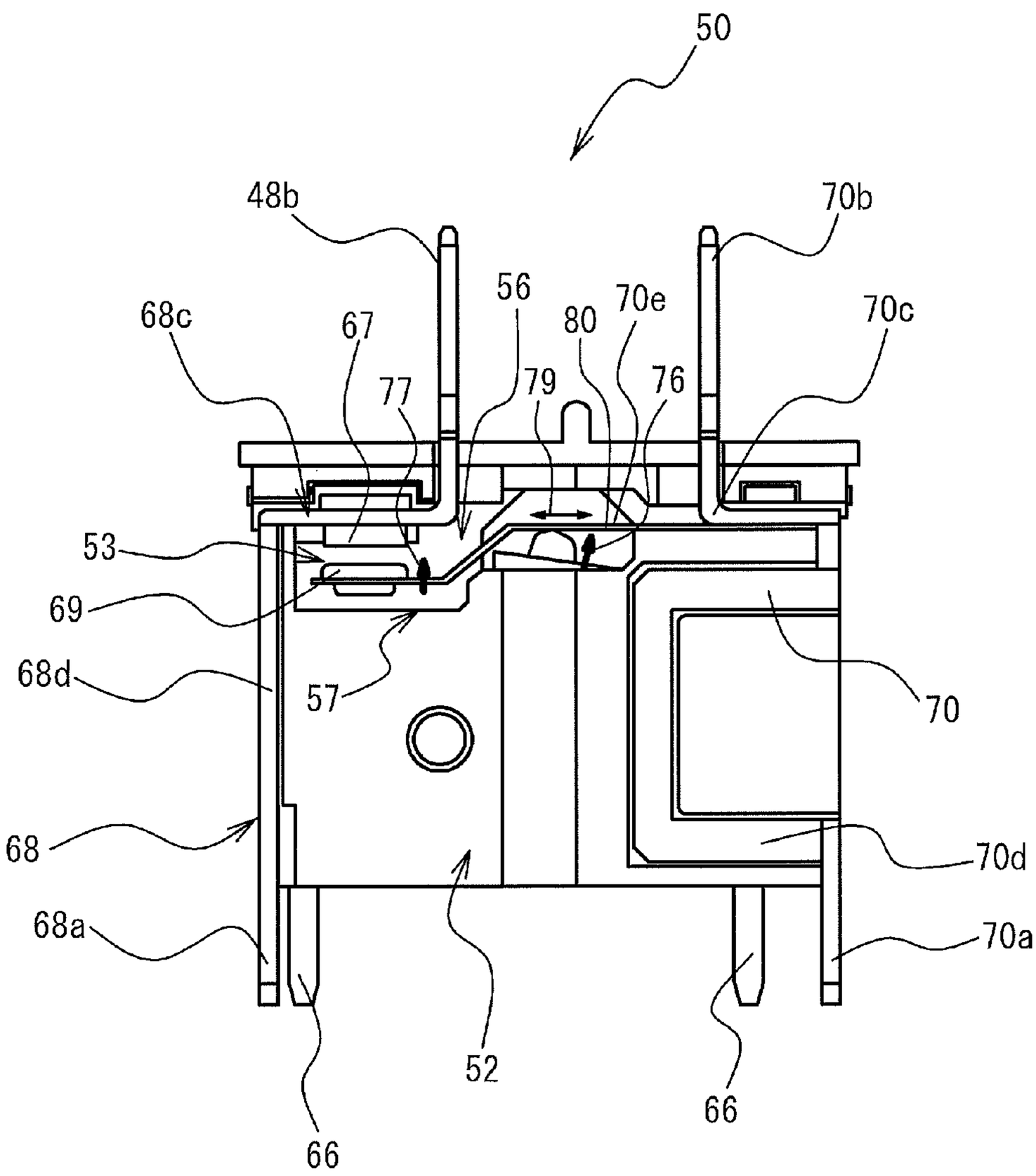
70a
61
66
58
62
68a
66

FIG. 4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48b
70b
68c
67
56
80
70e
70c
77
79
76
53
69
57
70
68d
68
70d
68a
70a
52
66
66

FIG. 5A

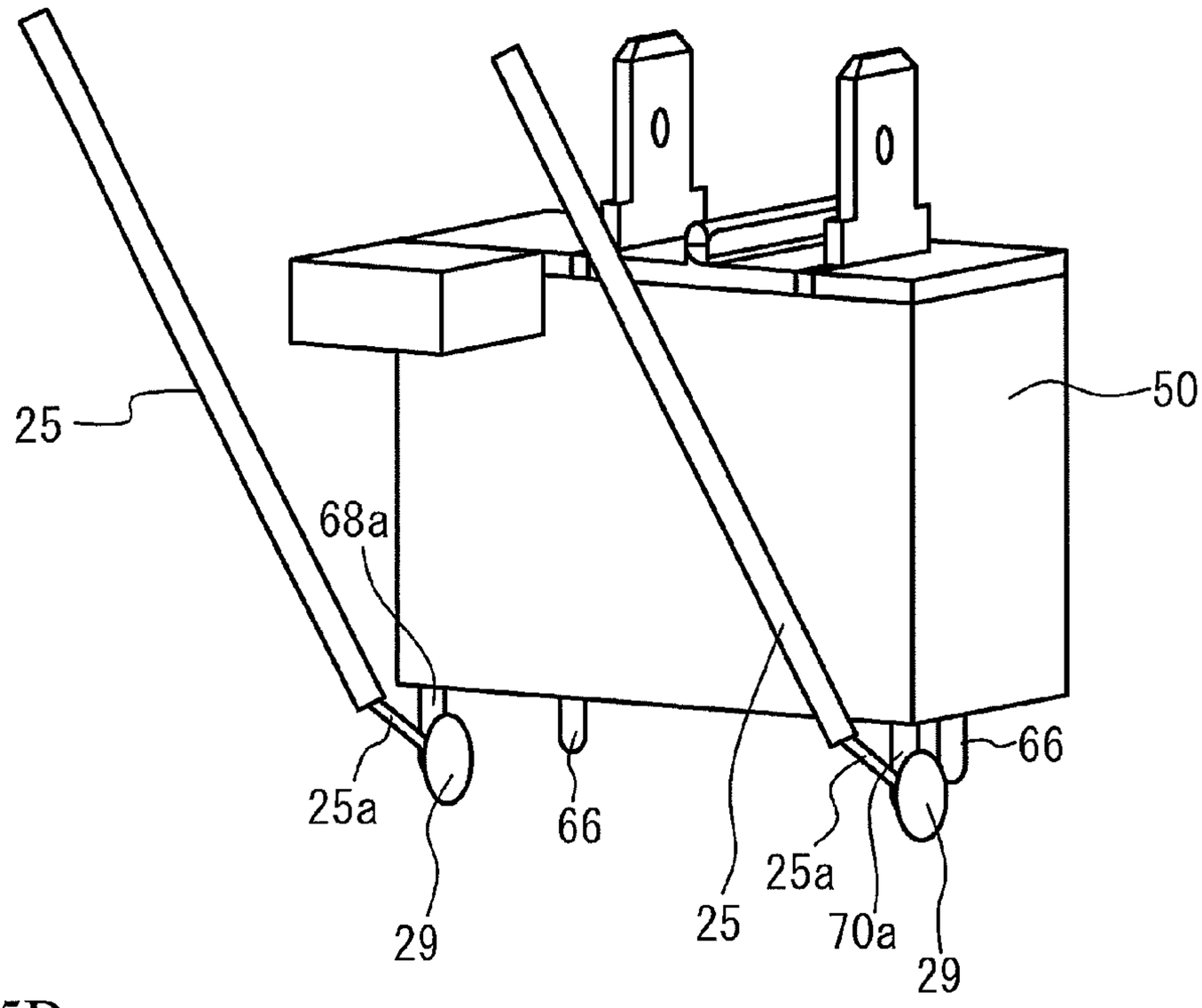

25
68a
25a
29
66
66
25
25a
70a
29
50

FIG. 5B

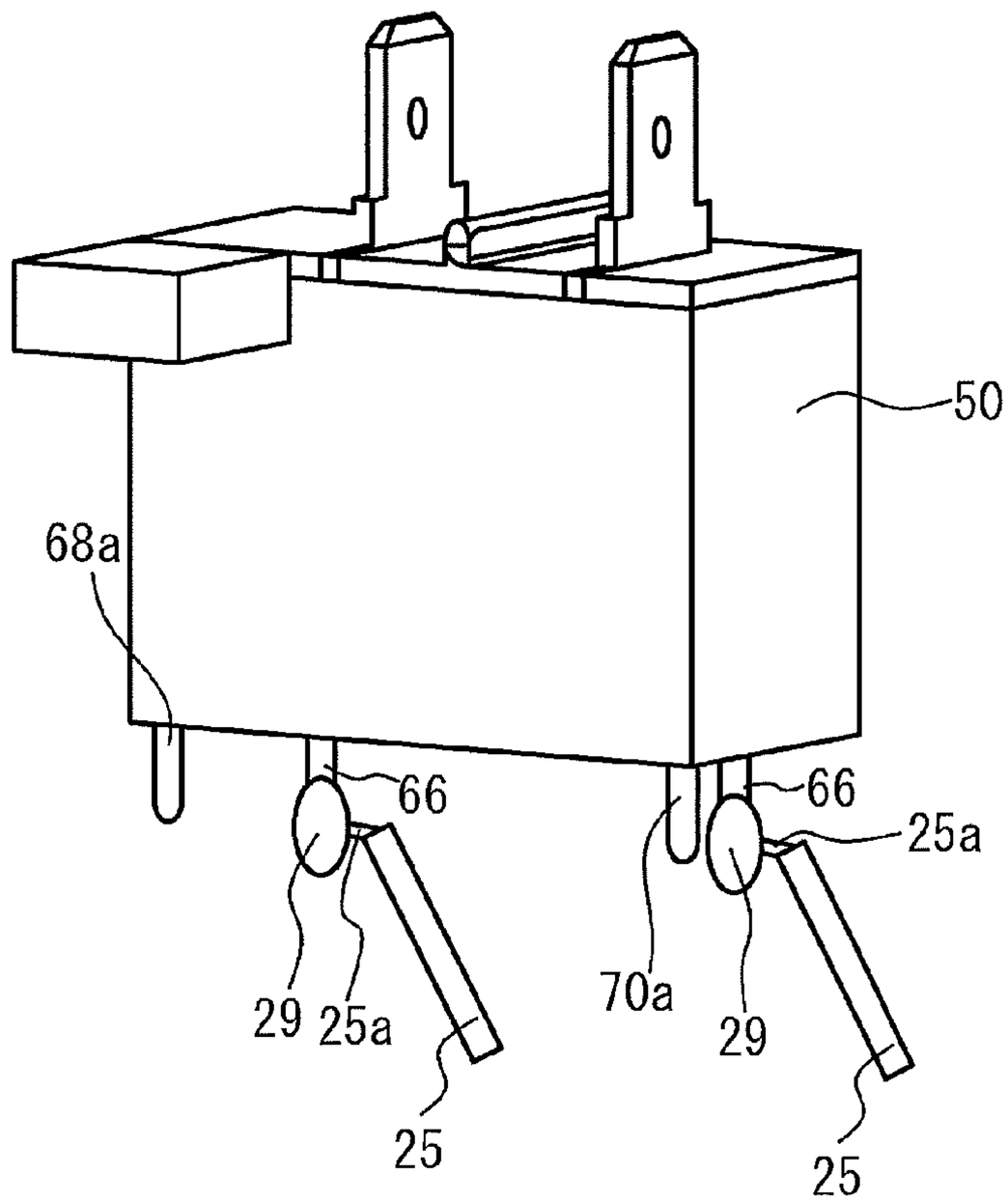

68a
66
66
25a
29
25a
25
70a
29
25
50

FIG. 6A

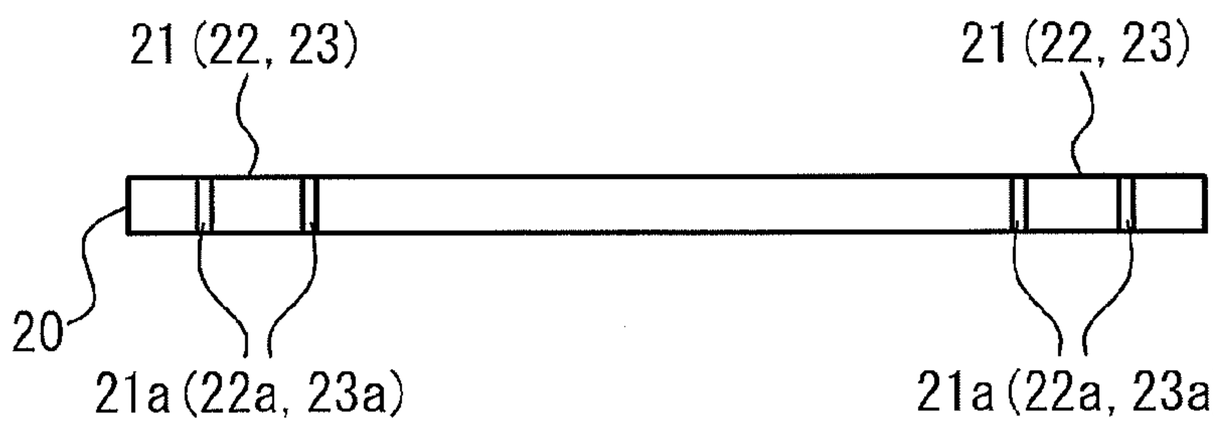


FIG. 6B

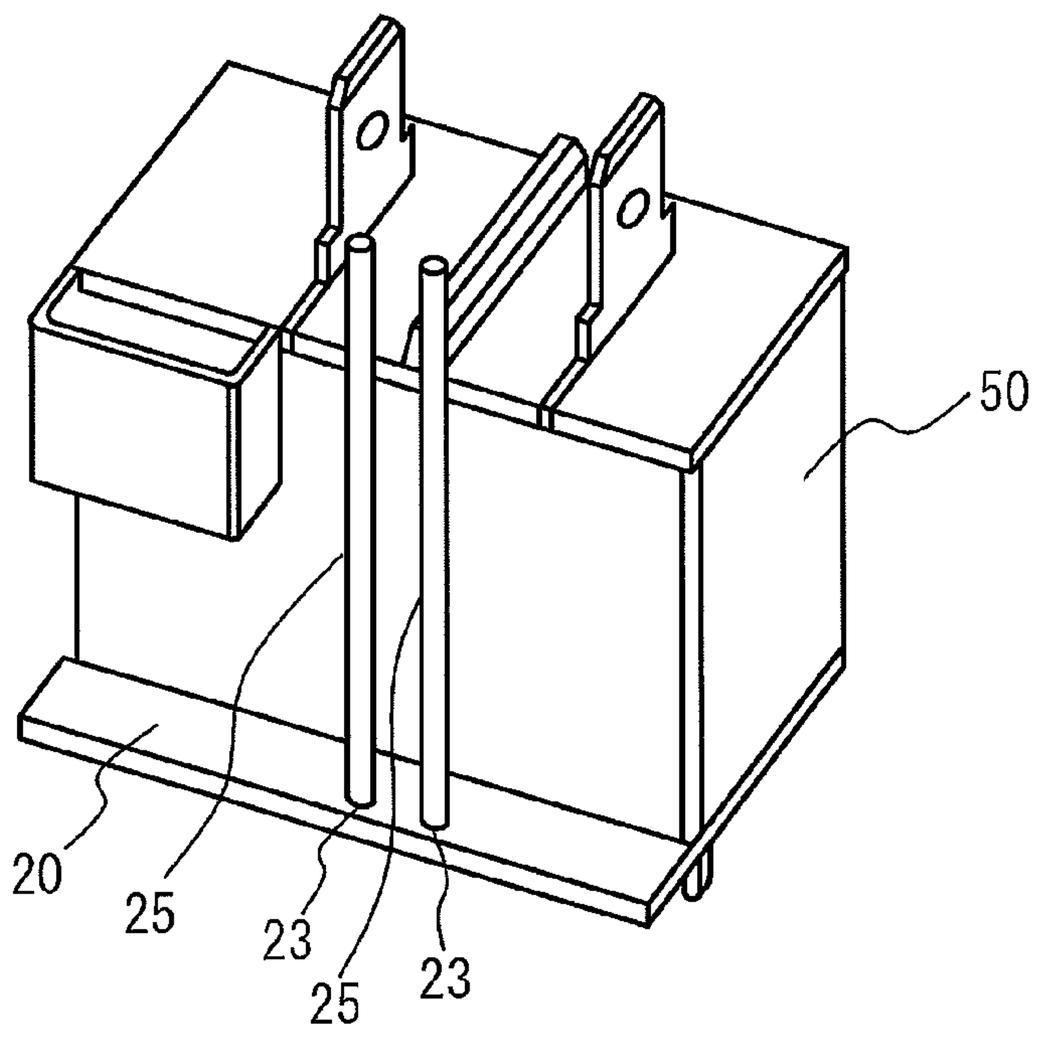


FIG. 7A

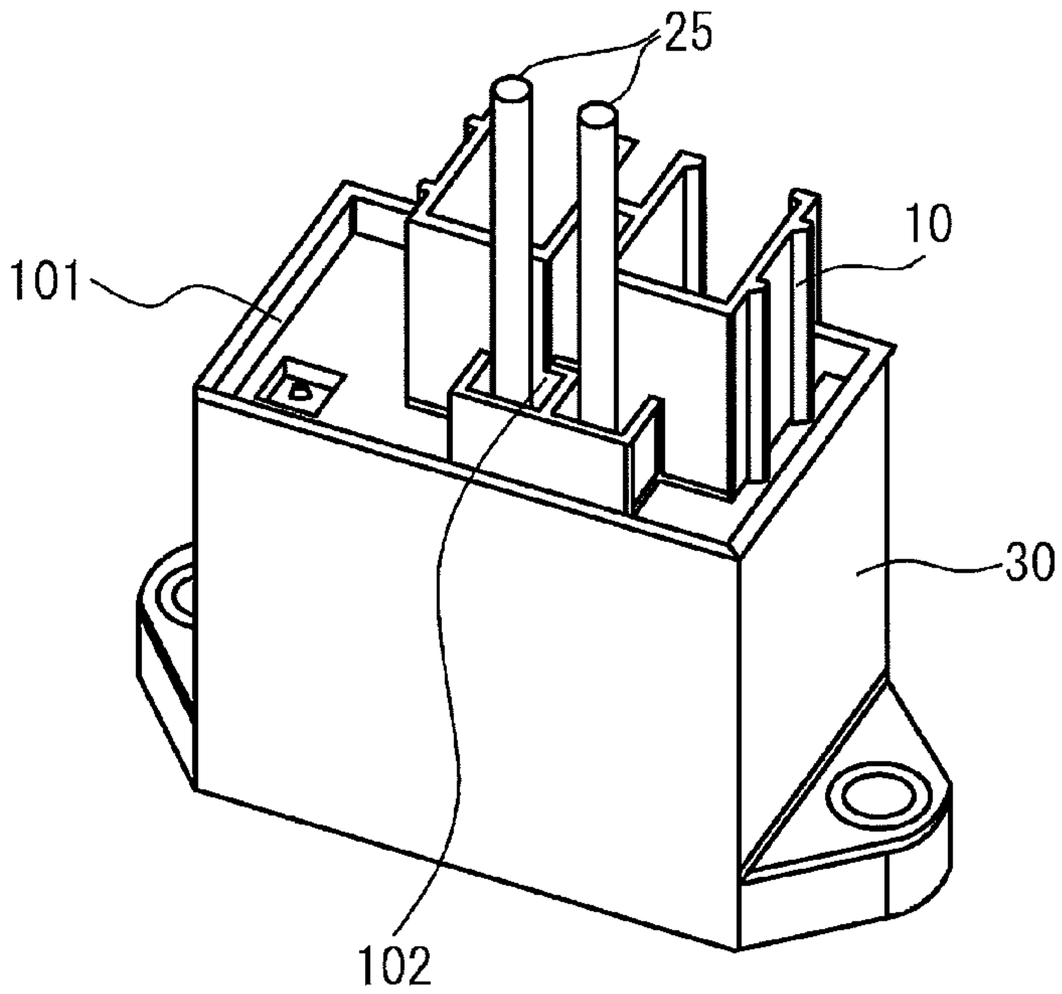


FIG. 7B

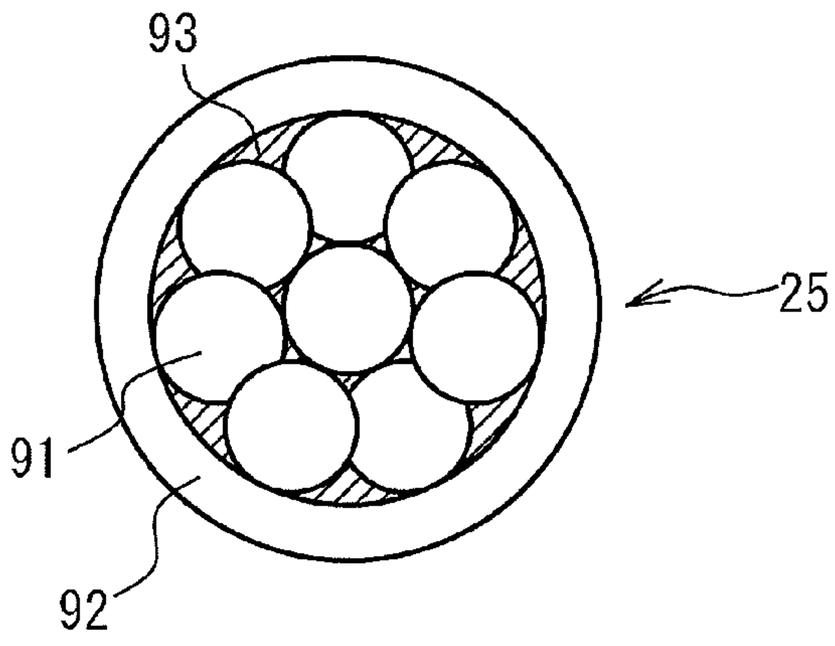


FIG. 8A

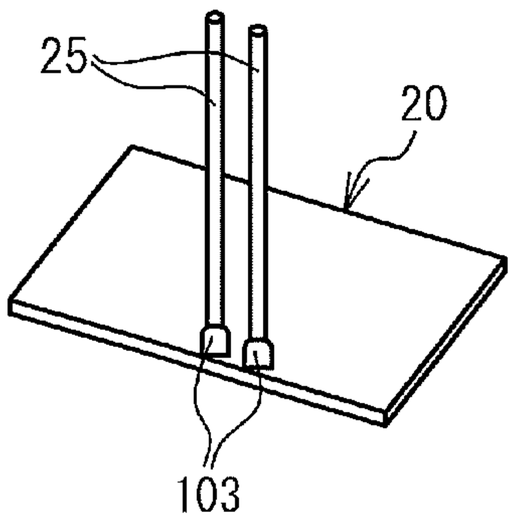


FIG. 8B

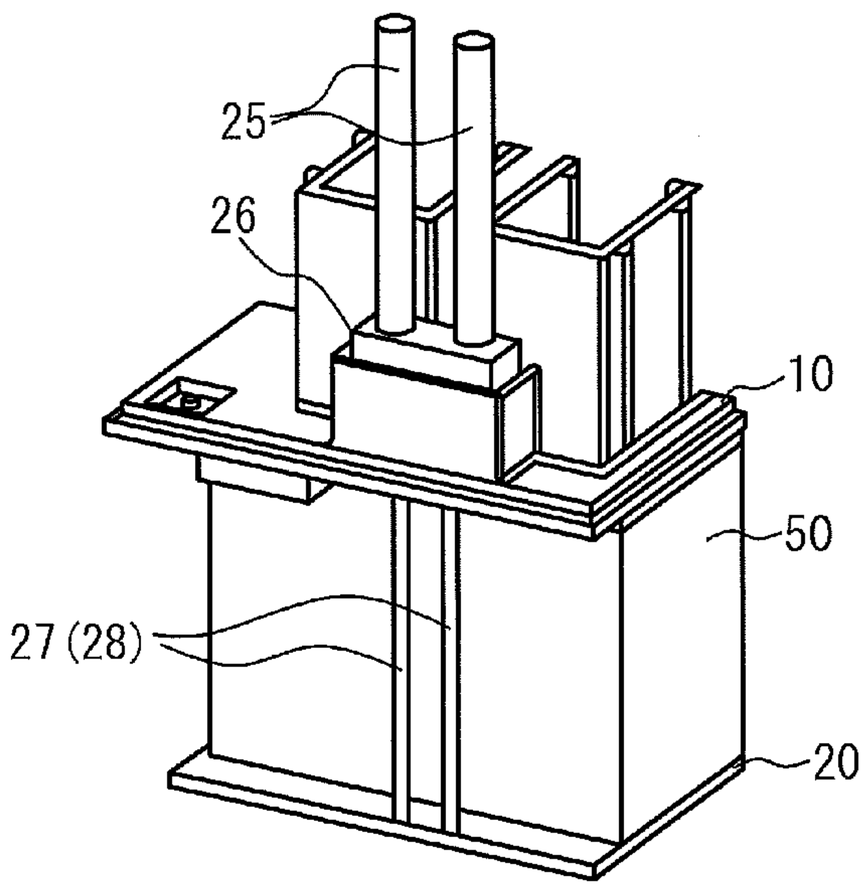


FIG. 8C

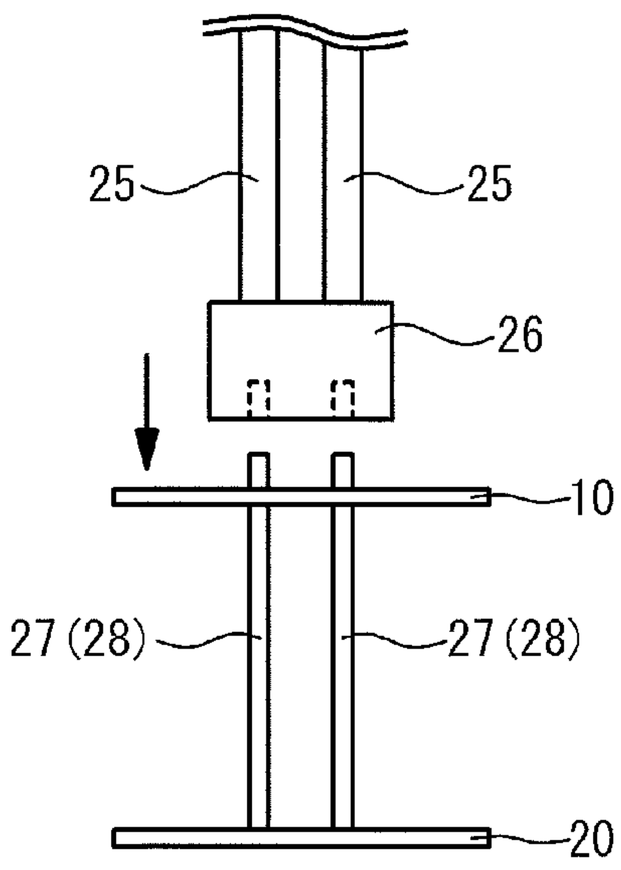


FIG. 9A

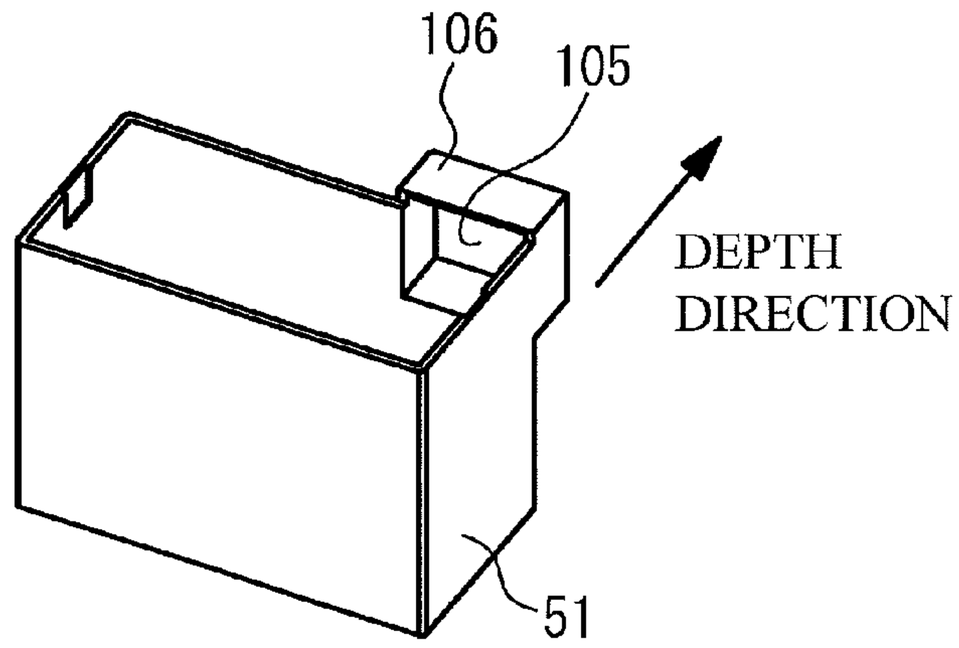


FIG. 9B

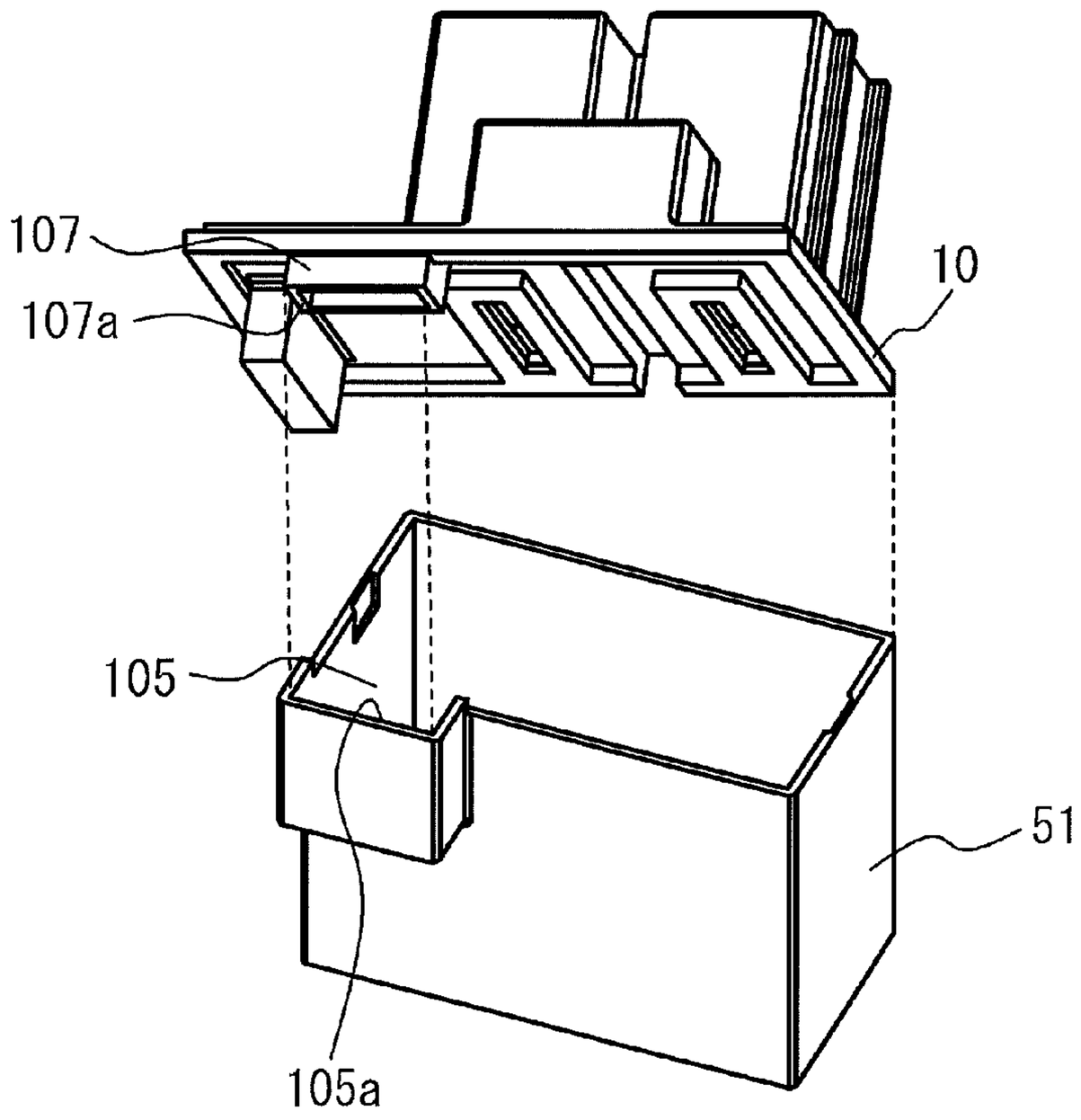


FIG. 10A

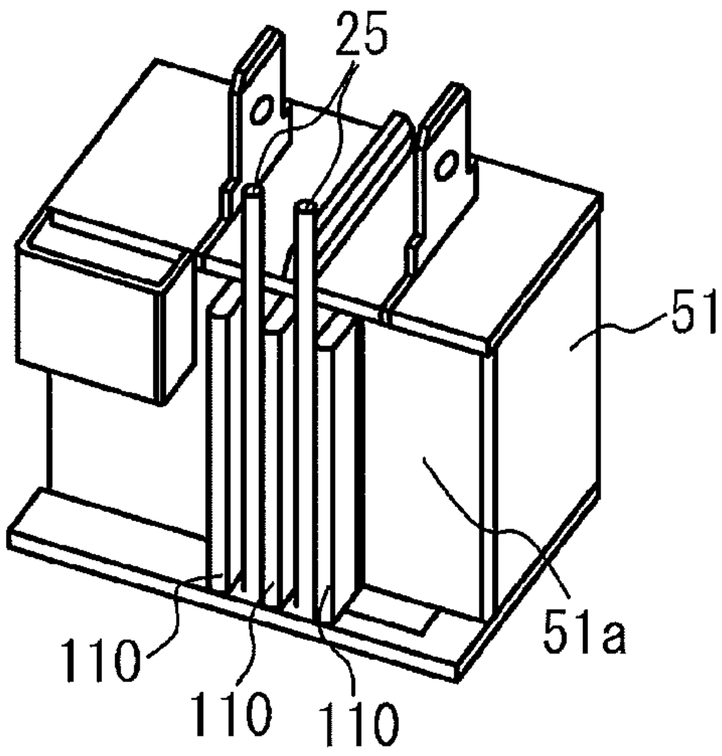


FIG. 10B

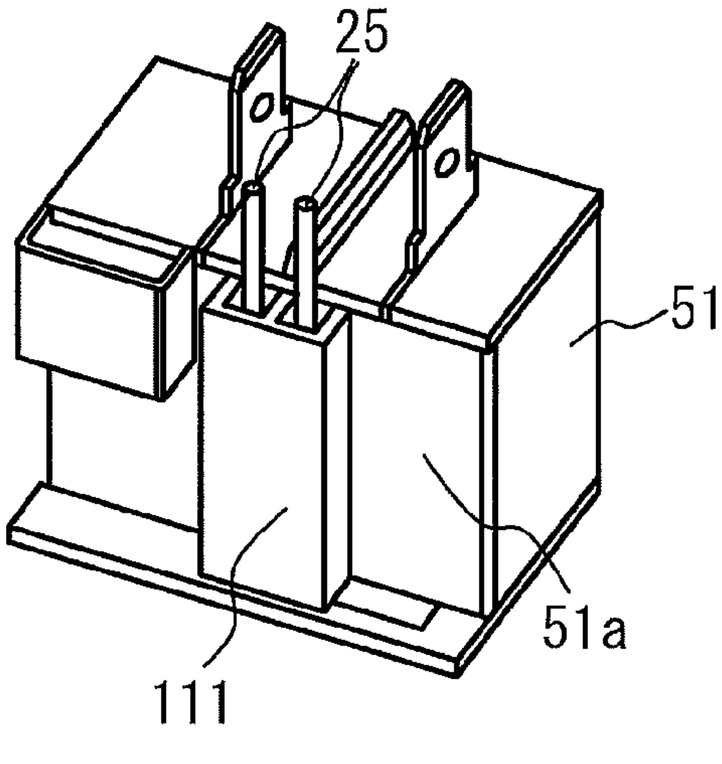


FIG. 10C

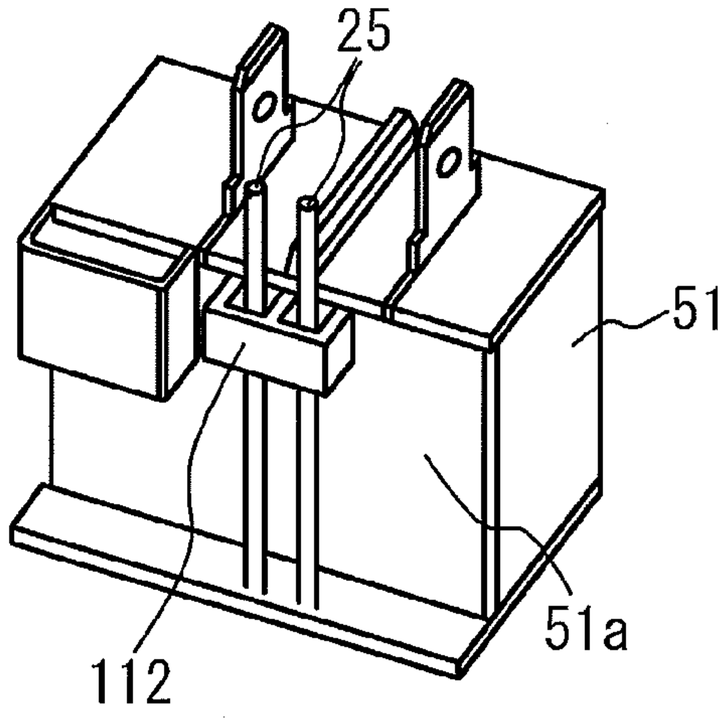


FIG. 11C

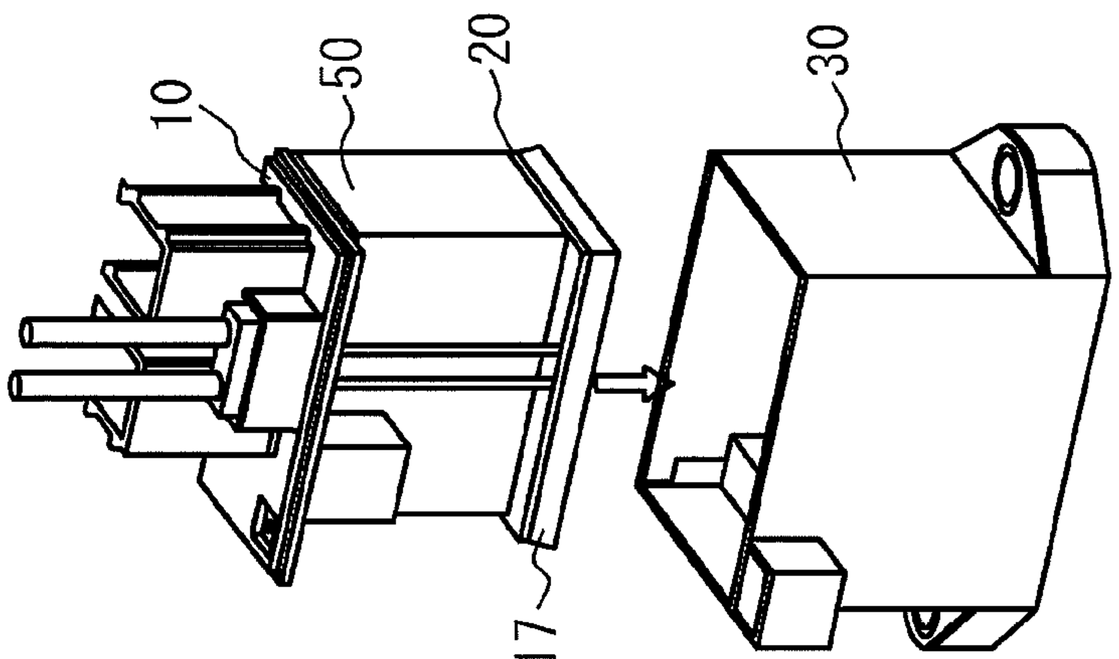


FIG. 11B

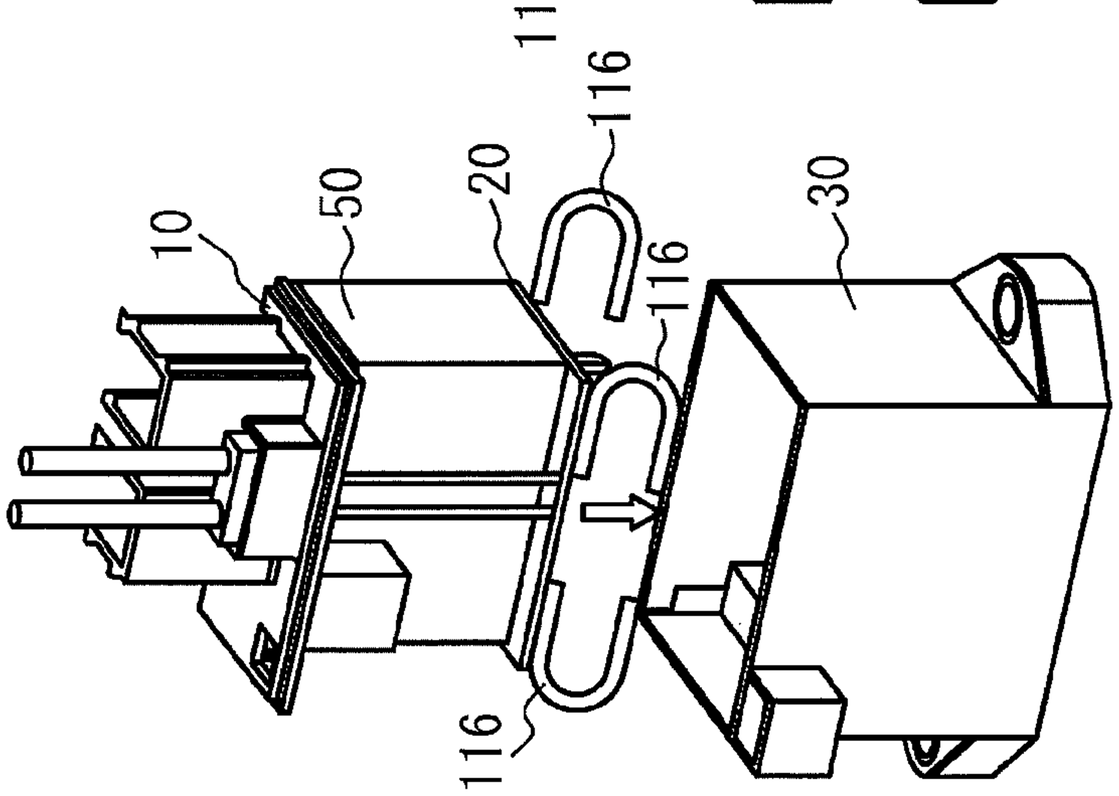


FIG. 11A

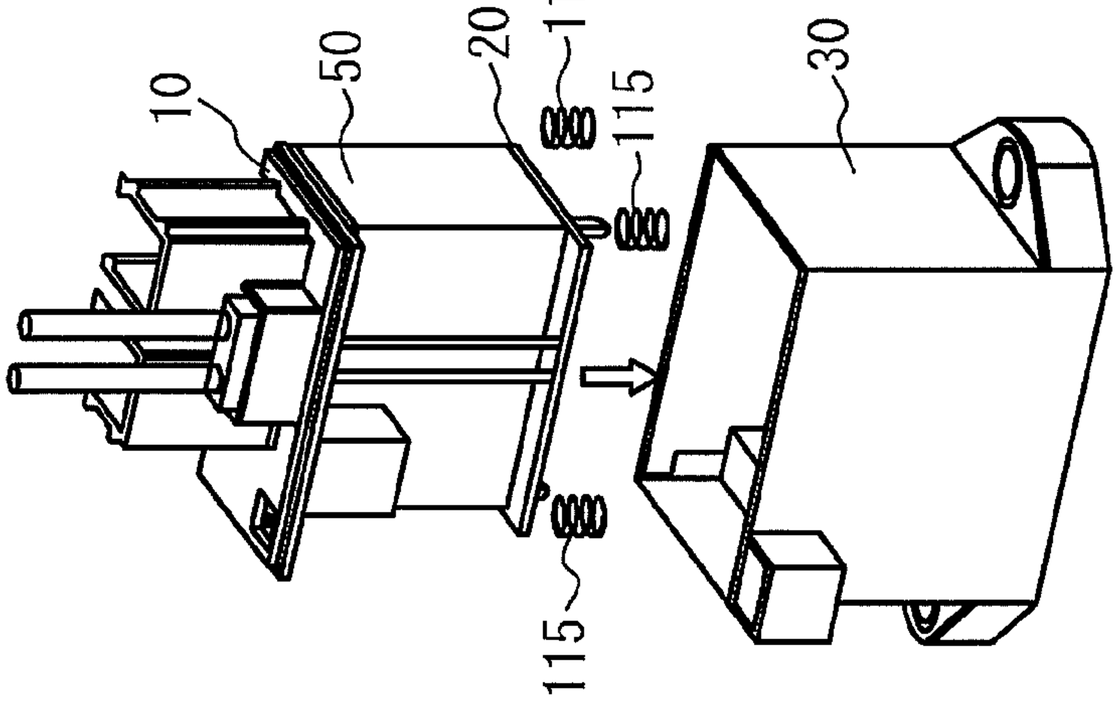


FIG. 12A

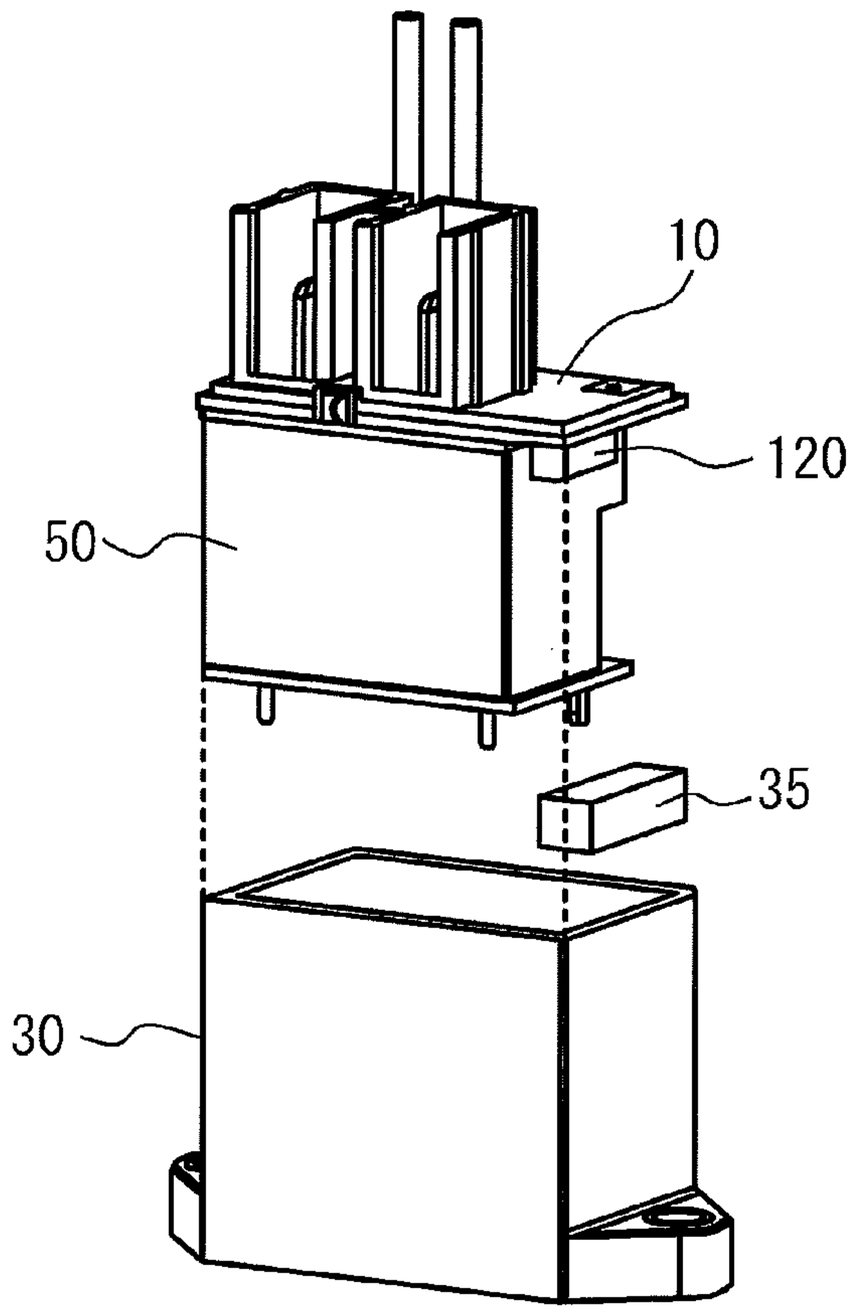


FIG. 12B

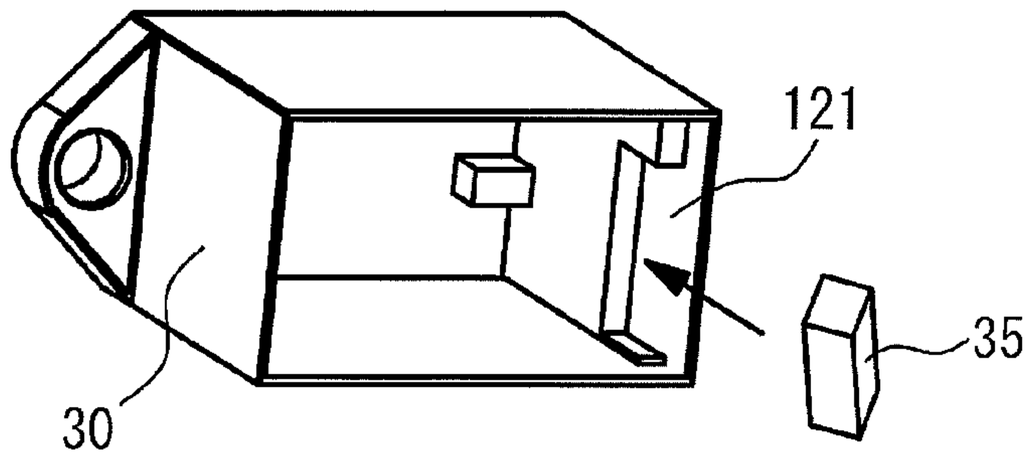


FIG. 13A

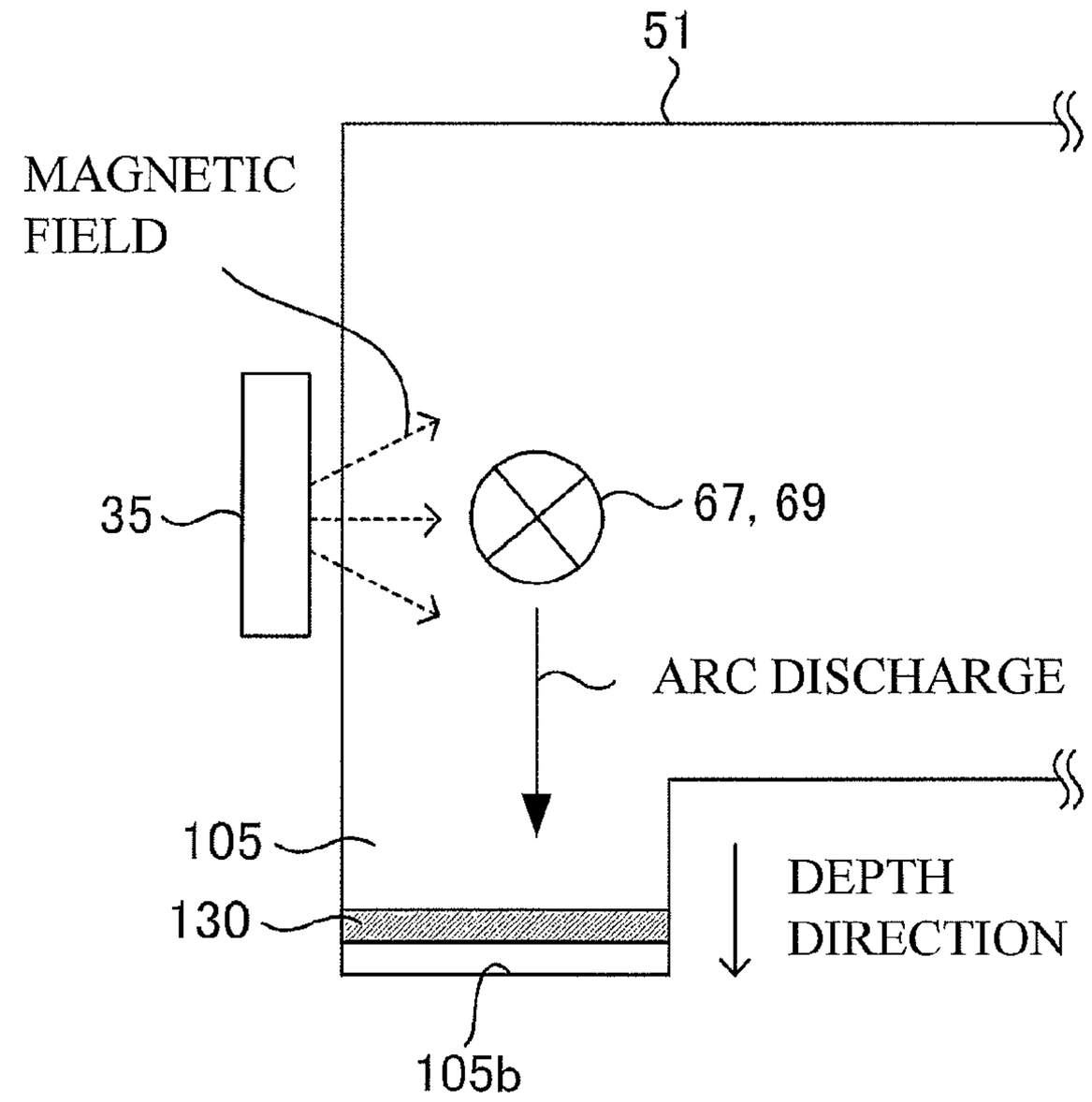


FIG. 13B

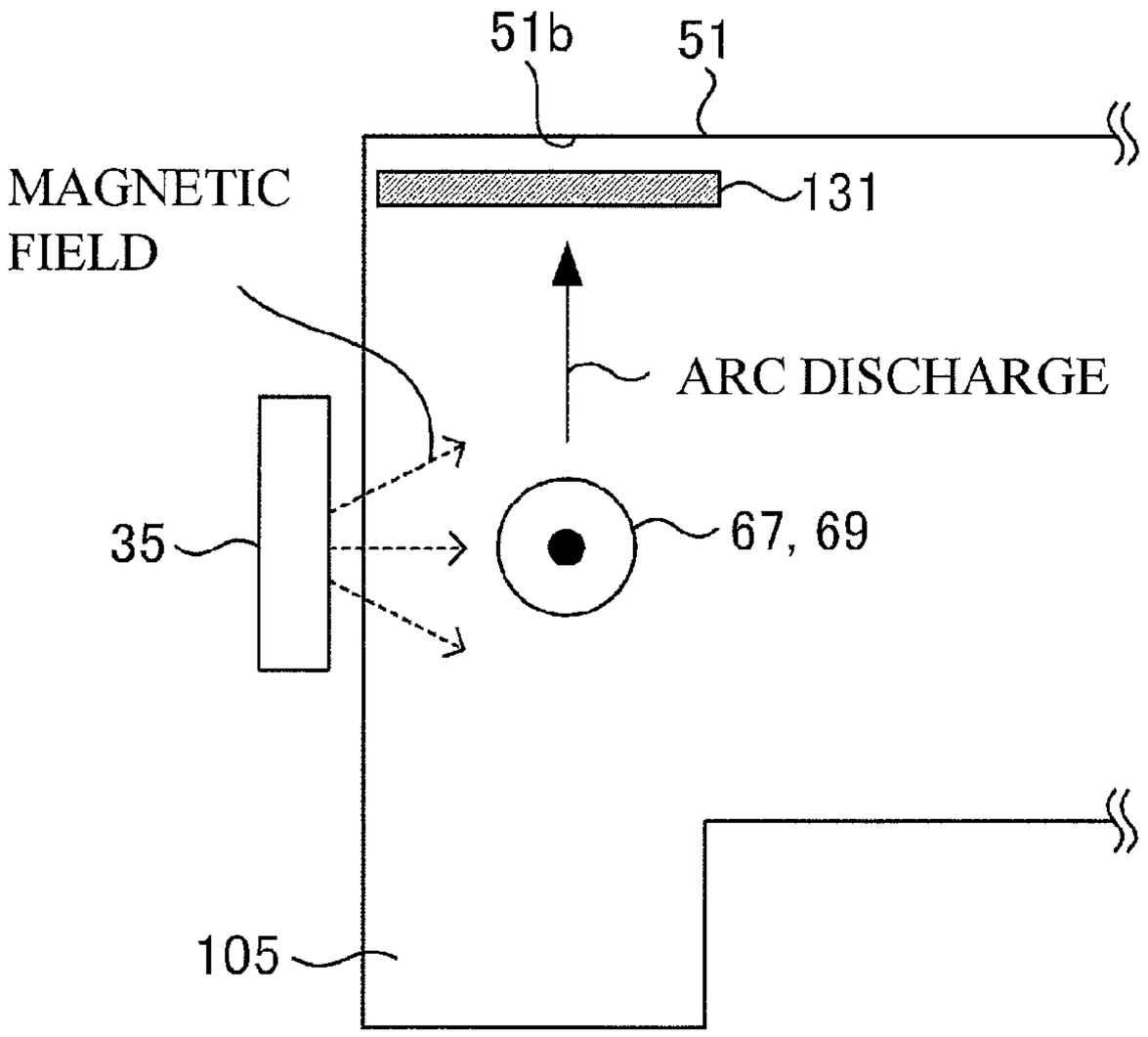


FIG. 14A

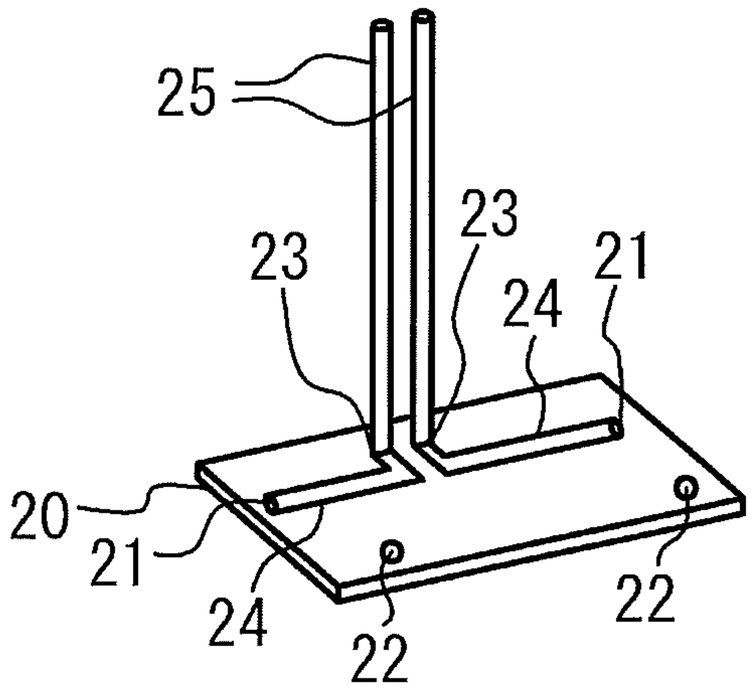
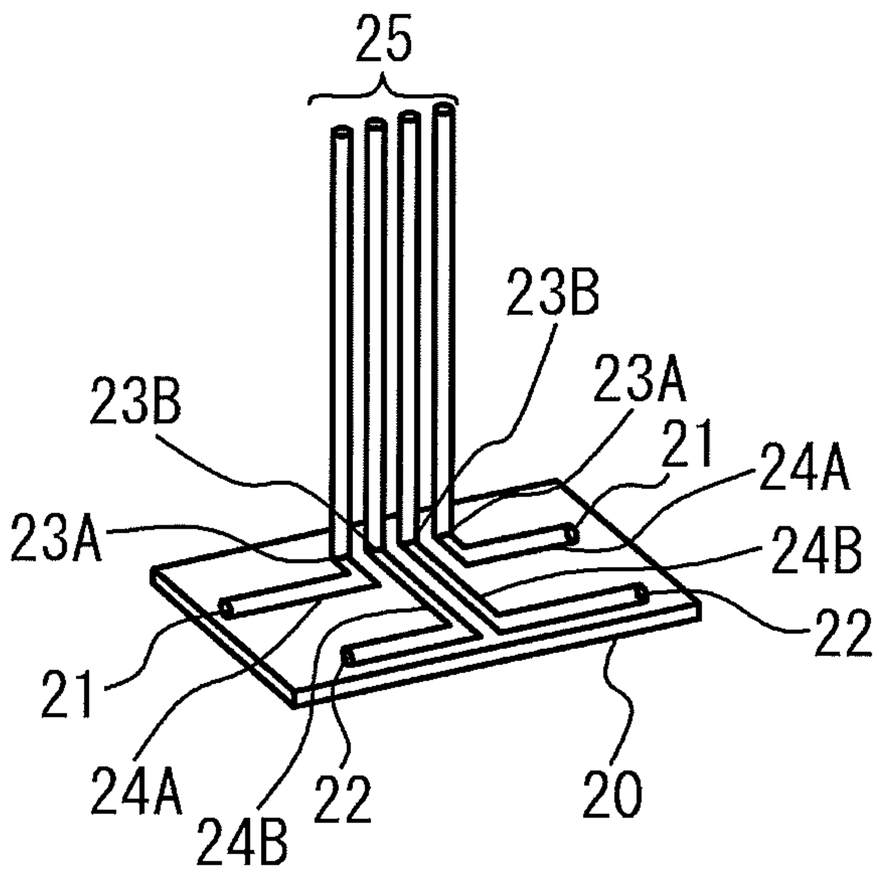


FIG. 14B



ELECTROMAGNETIC RELAY

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2012-102832 filed on Apr. 27, 2012, the entire contents of which are incorporated herein by reference.

FIELD

A certain aspect of the embodiments is related to an electromagnetic relay.

BACKGROUND

Conventionally, there has been known an electromagnetic relay **1** that includes: an electromagnet **2** in which an iron core is attached to a reel equipped with a coil; an armature **3** that moves depending on a voltage applied to the coil; and a contact portion **4** that opens and closes with the movement of the armature, as illustrated in FIG. **1**A (e.g. see Patent Document 1).

The electromagnetic relay **1** has a printed circuit board **5**. As illustrated in FIG. **1**B, the contact portion **4** is composed of a moving contact member **4***a* and a fixed contact member **4***b*. The moving contact member **4***a* and the fixed contact member **4***b* are made of a spring. Substrate terminals **6***a* and **6***b* of the moving contact member **4***a* and the fixed contact member **4***b* are fixed to a rear face of the printed circuit board **5**, as illustrated in FIG. **1**A. Tab terminals **7***a* and **7***b* are fixed to a right face of the printed circuit board **5**.

Patent Document 1: Japanese Laid-open Patent Publication No. 2011-228060

SUMMARY

According to an aspect of the present invention, there is provided an electromagnetic relay including: a main body including: a first cover; an electromagnet having a first terminal extending toward the outside from a bottom surface of the first cover; and a contact portion that opens and closes according to a magnetic attractive force of the electromagnet, and has a second terminal extending toward the outside from the bottom surface of the first cover; a cable line drawn out to the outside of the electromagnetic relay; and a printed circuit board that fixes the cable line to at least one of the first terminal and the second terminal by dip soldering, and electrically connects the cable line to the at least one of the first terminal and the second terminal.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1**A is an appearance diagram illustrating the construction of a conventional electromagnetic relay;

FIG. **1**B is a diagram illustrating the construction of a contact portion;

FIG. **2** is an exploded diagram of an electromagnetic relay according to the present embodiment;

FIG. **3** is a front view of a relay body in a state where an inner cover is removed;

FIG. **4** is a front view of the relay body seen from an opposite direction of FIG. **3**;

FIG. **5**A is a diagram illustrating an example in which cable lines are directly connected to substrate terminals by soldering;

FIG. **5**B is a diagram illustrating an example in which the cable lines are directly connected to coil terminals by soldering;

FIG. **6**A is a cross-section diagram of a printed circuit board corresponding to a line passing through through-holes;

FIG. **6**B is a diagram illustrating a state where the relay body and the cable lines are fixed on the printed circuit board;

FIG. **7**A is an appearance diagram illustrating the construction of the electromagnetic relay;

FIG. **7**B is a cross-section diagram of each cable line;

FIG. **8**A is a diagram illustrating an example in which connection places between the printed circuit board and the cable lines are sealed by protective material;

FIG. **8**B is a diagram illustrating an example in which metal lines or metal plates are used instead of the cable lines;

FIG. **8**C is a diagram illustrating an example in which a connector mounted to ends of the cable lines is attached to the metal lines or the metal plates;

FIG. **9**A is a diagram illustrating an example of the inner cover on which an arc space is formed;

FIG. **9**B is a diagram illustrating an example of an upper cover and the inner cover;

FIGS. **10**A to **10**C are diagrams illustrating examples of a support portion for supporting the cable lines, which is formed on a side surface of the inner cover;

FIGS. **11**A to **11**C are diagrams illustrating examples of a vibration dampener provided between the printed circuit board and an outer cover;

FIG. **12**A is a diagram illustrating an example of the upper cover on which a projection portion for pressing down a permanent magnet is formed;

FIG. **12**B is a diagram illustrating an example of the outer cover on which a recess for housing the permanent magnet is formed;

FIGS. **13**A and **13**B are diagrams illustrating position relationships between arc discharge and the arc space; and

FIGS. **14**A and **14**B are diagrams illustrating modification examples of the printed circuit board.

DESCRIPTION OF EMBODIMENTS

In the above-mentioned technology, when a connector, not shown, is electrically connected to the electromagnetic relay **1**, the cable lines which are connected to the substrate terminals **6***a* and **6***b* and are drawn out to the outside may be required. There is soldering as a method for connecting the cable lines to the substrate terminals **6***a* and **6***b*. However, when the cable lines are soldered to the substrate terminals **6***a* and **6***b* by hand, it is difficult to secure connection reliability, and manufacturing cost also rises since working man-hour increases. In addition, when both ends of the coil of the electromagnet **2** are also soldered to the cable lines drawn out to the outside, it is difficult to secure the connection reliability.

Therefore, there is a method in which the substrate terminals **6***a* and **6***b* and the tab terminals **7***a* and **7***b* are connected on the printed circuit board **5** with solder. However, since the soldering is performed on the right face and the rear face of the printed circuit board **5**, automatic soldering (solder dip) cannot be employed. In this case, the cable lines have to be

soldered to the substrate terminals **6***a* and **6***b* manually, so that it is difficult to secure the connection reliability.

Hereinafter, a description will be given of embodiments of the present invention with reference to the drawings.

FIG. **2** is an exploded diagram of an electromagnetic relay **100** according to the present embodiment. The electromagnetic relay **100** includes: an upper cover **10**; a relay body **50**; a printed circuit board **20**; cable lines **25**; an outer cover **30** as a second cover; and a permanent magnet **35**. The electromagnetic relay **100** is a direct-current high voltage relay with which an electric vehicle and a hybrid vehicle and so on are equipped, for example.

The upper cover **10** covers the relay body **50**. The upper cover **10** has a mounting unit **11** for mounting a socket which is coupled with tab terminals **68***b* and **70***b* of the relay body **50** described later.

The printed circuit board **20** includes: through-holes **21** for inserting substrate terminals **68***a* and **70***a* as second terminals described later; through-holes **22** for inserting coil terminals **66** as first terminals described later; and through-holes **23** for fixing the cable lines **25**. Conductive parts are formed on the inner circumference of the through-holes **21** to **23**. The through-holes **22** are electrically connected to the through-holes **23** by circuits **24**. The coil terminals **66** which have been inserted into and soldered with the through-holes **22** are electrically connected to the cable lines **25** fixed to the through-holes **23** via the circuits **24**.

The outer cover **30** houses the relay body **50**, the printed circuit board **20**, the cable lines **25**, and the permanent magnet **35**. The inside of the outer cover **30** becomes a sealed state by bonding the upper cover **10** onto the outer cover **30**. The screw holes **31** for mounting the outer cover **30** on the substrate **40** near a vehicle is provided in the outer cover **30**. The outer cover **30** is screwed onto the substrate **40** via the screw holes **31**. For the magnetic extinction of arc, the permanent magnet **35** is mounted in the outside of the relay body **50** and in the inside of the outer cover **30**.

The relay body **50** includes a base portion **52**, a hollow box-shaped inner cover **51** (a first cover), the substrate terminals **68***a* and **70***a*, and the tab terminals **68***b* and **70***b*. The substrate terminals **68***a* and **70***a* are illustrated in FIGS. **3** and **4**.

Since an assembly direction of respective parts is limited in an up-and-down direction as illustrated in FIG. **2**, the electromagnetic relay **100** according to the present embodiment is suitable for mass production.

FIG. **3** is a front view of the relay body **50** in a state where the inner cover **51** is removed. FIG. **4** is a front view of the relay body **50** seen from an opposite direction of FIG. **3**.

The substrate terminals **68***a* and **70***a* are provided on both ends of the relay body **50** respectively in order to increase connection strength with the printed circuit board **20**, as illustrated in FIGS. **3** and **4**. The tab terminals **68***b* and **70***b* are terminals in which a receptacle of a connector, not shown, is fitted.

The relay body **50** includes an electromagnet **58**, a switch **53**, a fixed contact member **68**, and a moving contact member **70**. The heat capacity of the fixed contact member **68** is larger than that of the moving contact member **70**. The fixed contact member **68** and the moving contact member **70** are formed by punching a conductive sheet metal in a predetermined shape and bending the punched sheet metal. The substrate terminal **68***a* and the tab terminal **68***b* are parts of the fixed contact member **68**, and the substrate terminal **70***a* and the tab terminal **70***b* are parts of the moving contact member **70**. Therefore, the substrate terminal **68***a* and the tab terminal **68***b* are brought into conduction. The substrate terminal **70***a* and the tab terminal **70***b* are brought into conduction.

One end of the switch **53** is connected to the moving contact member **70**. Another end of the switch **53** is a free end moving up and down. A fixed contact **67** which the fixed contact member **68** has contacts a moving contact **69** which the moving contact member **70** has, by action of the electromagnet **58**, and hence the switch **53** becomes a closed state. The operation of the switch **53** is described later in detail.

The base portion **52** includes: a first recess portion **55** that is made of resin with electric insulation and receives the electromagnet **58**; a second recess portion **56** that receives the switch **53**; and a partition **57** that delimits a border between the first recess portion **55** and the second recess portion **56** which are opposed to each other.

The electromagnet **58** includes: a spool **61**, a coil **62** wound around the spool **61**; and an iron core **63** (i.e., a dashed line unit inside the electromagnet **58**) attached to the spool **61**. The spool **61** is made of resin with electric insulation, and includes; a hollow body unit (not shown); a pair of brim units **61***a* and **61***b* that are coupled to both ends of the body unit in a longitudinal direction; and a pair of coil terminals **66** that are connected to both ends of the coil **62**.

The coil **62** is wound round the body unit of the spool **61**, and is fixedly held between the brim units **61***a* and **61***b* of the spool **61**. The iron core **63** is an approximate column-shaped member which is made of magnetic steel, for example. The iron core **63** is fixedly received in the body unit of the spool **61**.

A yoke **65** that forms a magnetic path around the coil **62** is fixedly coupled with the iron core **63** of the electromagnet **58** by caulking, for example. The yoke **65** is an L-shaped board member which is made of magnetic steel, for example. A short board portion of the yoke **65** is extended along the brim unit **61***b* of the spool **61**. A long board portion of the yoke **65** is arranged away from the side of the coil **62**, and extended substantially in parallel with the coil **62**.

An armature **60** is an L-shaped board member which is made of magnetic steel, for example. A flat plate portion **60***a* of the armature **60** is arranged in opposition to the iron core **63**. The armature **60** is operated by the electromagnet **58**. At the time of non-operation of the electromagnet **58**, the flat plate portion **60***a* of the armature **60** is held at a position separated from the iron core **63** by a given distance. When the electromagnet **58** operates, the flat plate portion **60***a* moves toward a direction (i.e., a direction of an arrow **75**) in which a bending portion of the armature **60** mainly approaches the iron core **63** according to a magnetic attractive force.

The switch **53** includes: the fixed contact **67** provided on the fixed contact member **68**; and the moving contact **69** provided on the moving contact member **70**. The fixed contact member **68** includes: the substrate terminal **68***a* to be fixed to the printed circuit board **20**; the tabular tab terminal **68***b*; a tabular intermediate portion **68***c* that substantially intersects perpendicularly with the substrate terminal **68***a* and the tab terminal **68***b*; and a leg portion **68***d* that extends from the intermediate portion **68***c* to the substrate terminal **68***a*. The fixed contact **67** is made of desired contact materials, and is fixed to the surface of the intermediate portion **68***c* of the side of the substrate terminal **68***a* by caulking, for example.

The moving contact member **70** includes: the substrate terminal **70***a* to be fixed to the printed circuit board **20**; the tabular tab terminal **70***b*; a tabular intermediate portion **70***c* that substantially intersects perpendicularly with the substrate terminal **70***a* and the tab terminal **70***b*; and a leg portion **70***d* that extends in the shape of a crank from the intermediate portion **70***c* to the substrate terminal **70***a*. A contact spring

element **70***e* which is composed of a thin board, such as phosphor bronze for spring, is coupled with the intermediate portion **70***c* by caulking, for example. The contact spring element **70***e* is extended in a direction that substantially intersects perpendicularly with the substrate terminal **70***a* and the tabular tab terminal **70***b*. The moving contact **69** is made of desired contact materials, and is fixed to a free end of the contact spring element **70***e* and the surface of the contact spring element **70***e* of the side of the tab terminal **70***b* by caulking, for example.

The intermediate portion **68***c* of the fixed contact member **68** is inserted into the second recess portion **56** of the base portion **52**, and is fixed to the base portion **52**. The intermediate portion **70***c* and the contact spring element **70***e* of the moving contact member **70** are inserted into the second recess portion **56** of the base portion **52**, and are fixed to the base portion **52**. When the fixed contact member **68** and the moving contact member **70** are mounted at a proper position on the base portion **52**, spaces are formed on and under the moving contact **69**, and the fixed contact **67** and the moving contact **69** are arranged so as to be opposed to each other via the space on the moving contact **69**.

An operation member **54** has bag structure which is made of resin with electric insulation. The operation member **54** is fixed to one end of the armature **60** opposite to another end of the armature **60** which approaches the iron core **63** of the electromagnet **58**. The operation member **54** has a projection **72** projected from a side opposite to the acceptance part **71**. The operation member **54** moves in a direction of an arrow **76** or a direction opposite to the arrow **76** in conjunction with oscillating movement of the armature **60** according to excitation or non-excitation of the electromagnet **58**.

A description will be given of the operation of the switch **53** with reference to FIGS. **3** and **4**.

When the electromagnet **58** operates, the flat plate portion **60***a* of the armature **60** moves in the direction of the arrow **75** approaching the iron core **63** against the spring power of the contact spring element **70***e* according to the magnetic attractive force. Thereby, the operation member **54** moves towards a limiting point **80** of a both-way oscillating range **79** while pushing the contact spring element **70***e*. That is, the operation member **54** elastically bends the contact spring element **70***e* in a direction of the arrow **76** so that the contact spring element **70***e* approaches the fixed contact member **68**. When the flat plate portion **60***a* of the armature **60** is perfectly adsorbed to the iron core **63**, the operation member **54** reaches the limiting point **80** of the both-way oscillating range **79**. The moving contact **69** moves in a direction of an arrow **77** in response to the operation of the operation member **54** and the armature **60**, contacts the fixed contact **67** and is electrically connected to the fixed contact **67**. Thereby, the switch **53** becomes a closed state.

On the other hand, when the current flowing through the electromagnet **58** is disconnected, the magnetic attractive force is lost and the flat plate portion **60***a* of the armature **60** moves in a direction opposite to the direction of the arrow **75**. Thereby, the operation member **54** moves toward a side opposite to limiting point **80** of the both-way oscillating range **79** (i.e., a left direction of FIG. **3**). Thereby, the moving contact **69** moves in a direction opposite to the direction of the arrow **77**, and separates from the fixed contact **67**. The switch **53** becomes an opened state.

In the present embodiment, a direction in which the current flows is specified as a direction toward the fixed contact **67** from the moving contact **69**. The moving contact **69** becomes a positive pole and the fixed contact **67** becomes a negative pole. In this case, arc discharge does not collide with the inner cover **51**, and hence generating an organic gas which causes degradation of opening-and-closing life of the switch **53** can be prevented. Therefore, the opening-and-closing life of the switch **53** is prolonged, compared with the case where the positive pole is set to the fixed contact **67**.

First Embodiment

A description will be given of a first embodiment.

When the sealed type electromagnetic relay **100** is produced, conductive parts **25***a* of the cable lines **25** drawn out to the outside are directly connected to the substrate terminals **68***a* and **70***a* by soldering (i.e., solder **29**), as illustrated in FIG. **5**A. However, when the conductive parts **25***a* of the cable lines **25** are directly connected to the substrate terminals **68***a* and **70***a*, it is necessary to solder the conductive parts **25***a* of the cable lines **25** to the substrate terminals **68***a* and **70***a* by hand. When the conductive parts **25***a* of the cable lines **25** are soldered to the substrate terminals **68***a* and **70***a* by hand, it is difficult to secure connection reliability, and manufacturing cost also rises since working man-hour increases. Similarly, when the conductive parts **25***a* of the cable lines **25** are soldered to the coil terminals **66** by hand, as illustrated in FIG. **5**B, it is difficult to secure connection reliability, and manufacturing cost also rises since working man-hour increases.

In the present embodiment, the printed circuit board **20** is prepared, as illustrated in FIG. **2**. As described above, the printed circuit board **20** includes: the through-holes **21** (second through-holes) for inserting the substrate terminals **68***a* and **70***a*; the through-holes **22** (first through-holes) for inserting the coil terminals **66** described later; and the through-holes **23** (third through-holes) for fixing the cable lines **25**. As illustrated in FIG. **6**A, conductive parts **21***a* to **23***a* are formed on the inner circumference of the through-holes **21** to **23**, respectively. FIG. **6**A is a cross-section diagram of the printed circuit board corresponding to a line passing through through-holes **21** (or through-holes **22** or **23**). The through-holes **22** are electrically connected to the through-holes **23** by the circuits **24**.

Next, the relay body **50** and the cable lines **25** are installed on the printed circuit board **20**. That is, the substrate terminals **68***a* and **70***a* of the relay body **50** are inserted into the through-holes **21**, the coil terminals **66** are inserted into the through-holes **22**, and the conductive parts **25***a* of the cable lines **25** are inserted into the through-holes **23**. Then, a dip soldering device, not shown, fixes the relay body **50** and the cable lines **25** on the printed circuit board **20** by dip soldering. The soldered coil terminals **66** are electrically connected to the cable lines **25** fixed into the through-holes **23**, via the circuits **24**. FIG. **6**B illustrates a state where the relay body **50** and the cable lines **25** are fixed on the printed circuit board **20**.

Since the through-holes **21** to **23** on a rear surface of the printed circuit board **20** are soldered by dip soldering, the relay body **50** and the cable lines **25** are fixed on the printed circuit board **20** simultaneously. The dip soldering has high connection reliability because of the established construction method. Since it is unnecessary to perform soldering by hand, the rise of the manufacturing cost can be restrained.

In FIG. **2**, the through-holes **22** are electrically connected to through-holes **23** by the circuits **24**. However, the through-holes **21** may be electrically connected to through-holes **23** by the circuits **24**, as illustrated in FIG. **14**A. In this case, the substrate terminals **68***a* and **70***a* are electrically connected to the cable lines **25**. As illustrated in FIG. **14**B, the through-holes **21** may be electrically connected to through-holes **23**A by the circuits **24**A and the through-holes **22** may be electrically connected to through-holes **23**B by the circuits **24**B. In

this case, the substrate terminals **68***a* and **70***a* are electrically connected to two cable lines **25**, and the pair of coil terminals **66** also are electrically connected to two remaining cable lines **25**.

Here, the printed circuit board **20** is not limited to circuitry of FIGS. **2**, **14**A and **14**B. For example, the number of through-holes **21** to **23** can be changed. Then, the printed circuit board **20** may include electronic circuits and electronic devices other than the above-mentioned circuits **24** (e.g. a filter circuit removing current noise, a voltage conversion circuit, and so on). In addition, the number of cable lines **25** is not limited to two or four.

Second Embodiment

A description will be given of a second embodiment.

In order to prevent the influence of the dust and harmful gas which have a bad influence on the contact reliability of a contact point, seal structure is required of the electromagnetic relay **100** to be installed in a vehicle. Even when an adhesive is applied to a gap **101** between the upper cover **10** and the outer cover **30** and a gap **102** between the upper cover **10** and the cable lines **25**, as illustrated in FIG. **7**A, the airtightness of the electromagnetic relay **100** may not be secured.

For example, each cable line **25** includes a plurality of conductors **91** and an insulating coat **92** covering the conductors **91**, as illustrated in FIG. **7**B. Since gaps **93** exist between the insulating coat **92** and the conductors **91**, the airtightness of the electromagnetic relay **100** cannot be secured.

Therefore, in the present embodiment, connection places of the printed circuit board **20** and the cable lines **25** are sealed by insulation protective materials **103**, as illustrated in FIG. **8**A. Thereby, access from the gaps **93** to the inside of electromagnetic relay **100** is obstructed, so that the airtightness of the electromagnetic relay **100** can be secured. Although insulation potting materials made of silicon or resin are used as the protective materials **103**, the potting materials made of other component may be used.

Instead of the cable lines **25**, which are covered by the outer cover **30**, arranged between the printed circuit board **20** and a top end of the inner cover **51** (i.e., the upper cover **10**), metal wires **27** such as tin-plated wires or metal plates **28** such as copper plates may be used, as illustrated in FIG. **8**B. In this case, the metal wires **27** or the metal plates **28** has no gaps **93**, and hence the airtightness of the electromagnetic relay **100** can be secured.

In this case, one ends of the metal wires **27** or the metal plates **28** are soldered to the printed circuit board **20** by the dip soldering, as illustrated in FIG. **8**C. Another ends of the metal wires **27** or the metal plates **28** are projected above the upper cover **10**. A connector **26** fixed to one ends of the cable lines **25** are attached to the another ends of the metal wires **27** or the metal plates **28**, so that the cable lines **25** are electrically connected to the printed circuit board **20**. After the connector **26** are attached to the another ends of the metal wires **27** or the metal plates **28**, an adhesive is applied to a gap between the connector **26** and the upper cover **10**.

Third Embodiment

A description will be given of a third embodiment.

In order to prevent dust from going into the inside of the relay body **50** at the time of manufacture of the electromagnetic relay **100**, the relay body **50** is covered with the inner cover **51**. On the other hand, the direct-current high voltage relay used in the present embodiment generates the arc discharge between the fixed contact **67** and the moving contact **69**. When the arc discharge contacts the inner cover **51**, an organic gas causing contact failure (i.e., poor electrical connection) is generated. Therefore, in order to cut off the arc discharge, a space (hereinafter referred to as "an arc space") which prolongs the arc discharge needs to be provided on the inner cover **51**.

Here, it is considered that an arc space **105** as illustrated in FIG. **9**A is provided in the inner cover **51**. In this case, the arc space **105** is integrally formed with the inner cover **51**, and the wall portion **106** is formed as the upper surface of the arc space **105**. Therefore, in order to form the arc space **105** of FIG. **9**A, a metal mold which can slide in a depth direction of the arc space **105**, i.e., a metal mold which has slide structure is required. In general, the metal mold which has slide structure is expensive.

In the present embodiment, a projection portion **107** (a first projection portion) for preventing invasion of foreign substances, such as dust, is formed on the rear surface of the upper cover **10**, as illustrated in FIG. **9**B. Thereby, the wall portion **106** to be formed as the upper surface of the arc space **105** is removed. That is, an upside of the arc space **105** integrally formed on an upper part of the side surface of the inner cover **51** is opened. The projection portion **107** is provided at a position opposite to the arc space **105**. The projection portion **107** is formed so that the outer circumference **107***a* of the projection portion **107** is attached firmly to the inner circumference **105***a* of the arc space **105** which is a part of the inner cover **51**. In addition, the projection portion **107** has a height which prevents invasion of the foreign substances and in which the arc discharge does not contact the projection portion **107**.

According to the present embodiment, it is possible to prevents invasion of the foreign substances, such as dust, by combination of the upper cover **10** and the inner cover **51**. Moreover, the metal mold which has slide structure is not required, so that the manufacturing cost of the electromagnetic relay **100** can be reduced. Further, as compared with a case where the metal mold which has slide structure is used, the formation time of the inner cover **51** which has the arc space **105** is shortened, so that the productivity of the electromagnetic relay **100** improves.

Fourth Embodiment

A description will be given of a fourth embodiment.

As described above, when the cable lines **25** are soldered to the printed circuit board **20** by dip soldering, the cable lines **25** are in an unstable state, and hence it is difficult to perform the soldering. It is assumed that a relay unit including the relay body **50**, the cable lines **25**, and the printed circuit board **20** as illustrated in FIG. **6** is manufactured. In a manufacturing floor, a plurality of sets of the relay body **50** and the cable lines **25** are arranged on a single large printed circuit board, and the large printed circuit board is cut for every relay unit after the soldering. Thereby, a plurality of relay units are formed. At this time, the cable lines **25** of a certain relay unit fall over an adjoining relay unit, so that it is impossible to cut the large printed circuit board.

Therefore, in the present embodiment, a support portion for supporting the cable lines **25** is integrally formed with a side surface **51***a* of the inner cover **51** adjacent to the cable lines **25**. Here, the support portion is post-attached to the side surface **51***a* of the inner cover **51**. That is, the support portion may be detachable from the side surface **51***a*.

In FIG. **10**A, a comb-shaped projection portion **110** (a second projection portion) for sandwiching the cable lines **25** is integrally formed with the side surface **51***a*, as the support

portion. The projection portion **110** is extended in a direction away from the inner cover **51**. In FIG. **10**B, a tube portion **111** covering the cable lines **25** is integrally formed with the side surface **51***a*, as the support portion. The tube portion **111** is extended toward a lower end of the inner cover **51** from an upper end thereof. In FIG. **10**C, a ring portion **112** supporting each cable line **25** at a point is integrally formed with the side surface **51***a*, as the support portion. The ring portion **112** is formed on the upper part of the side surface **51***a* in order to prevent the cable lines **25** from falling down.

The support portion is not limited to the projection portion **110**, the tube portion **111**, and the ring portion **112**. Moreover, although a horizontal cross-sectional shape of the inner circumference of the tube portion **111** and the ring portion **112** is a rectangle, the horizontal cross-sectional shape may be a circle, a triangle, or a polygon.

According to the present embodiment, the support portion for supporting the cable lines **25** is integrally formed with the side surface **51***a* of the inner cover **51** adjacent to the cable lines **25**, so that it is prevent the cable lines **25** from falling down. As a result, the work which solders the cable lines **25** to the printed circuit board **20** becomes easy.

Fifth Embodiment

A description will be given of a fifth embodiment.

As illustrated in FIG. **2**, the outer cover **30** houses the printed circuit board **20** to which the relay body **50** and the cable lines **25** have been soldered. At this time, since the printed circuit board **20** directly contacts the outer cover **30**, a contact sound of the printed circuit board **20** and the outer cover **30** occurs by vibration which arises in the relay body **50**. Therefore, noise reduction of the electromagnetic relay **100** cannot be secured.

In the present embodiment, a vibration absorber for absorbing vibration which arises in the relay body **50** is provided between the printed circuit board **20** and the outer cover **30**, as illustrated in FIGS. **11**A to **11**C. In FIG. **11**A, springs **115** are used as the vibration absorber. In FIG. **11**B, U-shaped springs **116** are used as the vibration absorber. In FIG. **11**C, a damper **117** is used as the vibration absorber. The damper **117** is made of rubber, urethane, or silicon, but is not limited to this.

According to the present embodiment, the vibration absorber is provided between the printed circuit board **20** and the outer cover **30**. Therefore, the contact sound of the printed circuit board **20** and the outer cover **30** does not occur, and hence the noise reduction of the electromagnetic relay **100** can be secured.

Sixth Embodiment

A description will be given of a sixth embodiment.

In the sealed type relay which uses a permanent magnet for the magnetic extinction, a total of two adhesion processes is required, as in the case of fixing the permanent magnet to a housing and as in the case of fixing the upper cover to the housing.

In the present embodiment, a projection portion **120** (a third projection portion) for pressing a permanent magnet **35** for the magnetic extinction is provided on the rear surface of the upper cover **10**, as illustrated in FIG. **12**A. In addition, a recess **121** for housing the permanent magnet **35** is provided on the inner wall of the outer cover **30**, as illustrated in FIG. **12**B. By sandwiching the permanent magnet **35** between the projection portion **120** and the recess **121**, the permanent magnet **35** is fixed. Thereby, the adhesion process required for fixing the permanent magnet **35** to the outer cover **30** can be removed.

A samarium-cobalt magnet which is excellent at maintenance of a residual magnetic flux density, and the usage environment in high temperature is employed as the permanent magnet **35**. Thereby, the relay can be downsized, i.e., an implementation area of the relay can be reduced. In a neodymium magnet, the residual magnetic flux density reduces with temperature, for example. Therefore, it is desirable that the above-mentioned samarium-cobalt magnet is employed as the permanent magnet **35**.

Seventh Embodiment

A description will be given of a seventh embodiment.

As described above, in the electromagnetic relay **100**, the arc space **105** is integrally formed on the upper part of the side surface of the inner cover **51**. The arc discharge is extended in the direction of the arc space **105** and is cut off. However, when the direction of the current flowing through the fixed contact **67** and the moving contact **69** is opposite to a direction that the user intends, the arc discharge is extended in the direction opposite to the direction of the arc space **105**. In this case, the arc discharge contacts the inner cover **51**, and the organic gas causing the contact failure (i.e., poor electrical connection) is generated.

FIGS. **13**A and **13**B are diagrams illustrating position relationships between the arc discharge and the arc space. In FIG. **13**A, the direction of the current flowing through the fixed contact **67** and the moving contact **69** is downward vertically against the page space. In FIG. **13**B, the direction of the current flowing through the fixed contact **67** and the moving contact **69** is upward vertically against the page space.

In FIG. **13**A, the arc discharge which arises between the fixed contact **67** and the moving contact **69** receives a Lorentz force by a magnetic field from the permanent magnet **35** and is extended in the direction of the arc space **105**. In FIG. **13**A, a cooling member **130** for cooling the extended arc discharge is provided on the inside of the arc space **105**. Specifically, the cooling member **130** is arranged on the inside of the arc space **105** and arranged in a direction perpendicular to the depth direction (i.e., a direction of movement of the arc discharge) of the arc space **105**. That is, the cooling member **130** is arranged on the inside of the arc space **105** and arranged in parallel with an inner wall **105***b* of the arc space **105**. The cooling member **130** is a metal plate or a ceramic board, for example.

In FIG. **13**B, the arc discharge which arises between the fixed contact **67** and the moving contact **69** receives the Lorentz force by the magnetic field from the permanent magnet **35** and is extended in a direction of an inner wall **51***b* of the inner cover **51** opposite to the arc space **105**. In FIG. **13**B, a cooling member **131** for cooling the extended arc discharge is provided at a position opposite to the arc space **105**. Also, the cooling member **131** is arranged in parallel with the inner wall **51***b* of the inner cover **51** or arranged in a direction perpendicular to the direction of movement of the arc discharge. The cooling member **131** may be suspended from the base portion **52** or may be fixed to a member, not shown. The cooling member **131** is a metal plate or a ceramic board, for example. Even when the arc discharge is extended in a direction opposite to the direction of the arc space **105** as illustrated in FIG. **13**B, the cooling member **131** can cool the arc discharge and cut off the arc discharge.

In the present embodiment, at least one of the cooling members **130** and **131** may be provided depending on the direction of the current flowing through the fixed contact **67** and the moving contact **69**.

In the present embodiment, the cooling member **130** is provided on the inside of the arc space **105** and/or the cooling member **131** is provided at the position opposite to the arc space **105**. Therefore, at least one of the cooling members **130** and **131** can cool the arc discharge and cut off the arc discharge. As a result, the opening-and-closing performance of the fixed contact **67** and the moving contact **69** can be improved.

All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various change, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. An electromagnetic relay comprising:

a main body including:

a first cover;

an electromagnet having a first terminal extending toward the outside from a bottom surface of the first cover; and

a contact portion that opens and closes according to a magnetic attractive force of the electromagnet, and has a second terminal extending toward the outside from the bottom surface of the first cover;

a cable line drawn out to the outside of the electromagnetic relay; and

a printed circuit board that fixes the cable line to at least one of the first terminal and the second terminal by dip soldering, and electrically connects the cable line to the at least one of the first terminal and the second terminal.

2. The electromagnetic relay as claimed in claim **1**, wherein the printed circuit board includes a first through-hole for inserting the first terminal, a second through-hole for inserting the second terminal, a third through-hole for inserting the cable line, and a circuit that electrically connect at least one of the first through-hole and the second through-hole to the third through-hole.

3. The electromagnetic relay as claimed in claim **1**, further comprising:

an upper cover that is placed on an upper surface of the main body; and

a second cover that houses the main body, the cable line, and the printed circuit board, and is fixed to the upper cover.

4. The electromagnetic relay as claimed in claim **1**, wherein a portion of the printed circuit board which contacts with the cable line is sealed by a protective material.

5. The electromagnetic relay as claimed in claim **4**, wherein the protective material is an insulation potting material.

6. The electromagnetic relay as claimed in claim **1**, wherein the cable line is at least either one of a metal wire or a metal plate, and is provided between the printed circuit board and a top end of the first cover.

7. The electromagnetic relay as claimed in claim **3**, wherein the first cover includes a space for prolonging arc discharge which arises in the contact portion at an upper part of a side surface of the first cover, an upside of the space being opened, and

the upper cover includes a first projection portion that projects from a rear surface of the upper cover at a position opposite to the space.

8. The electromagnetic relay as claimed in claim **1**, wherein the first cover includes a support portion for supporting the cable line on a side surface adjacent to the cable line.

9. The electromagnetic relay as claimed in claim **8**, wherein the support portion is any one of a comb-shaped second projection portion sandwiching the cable line, a tube portion covering the cable line, and a ring portion supporting the cable line at a point.

10. The electromagnetic relay as claimed in claim **3**, wherein a vibration absorber for absorbing vibration is provided between the printed circuit board and the second cover.

11. The electromagnetic relay as claimed in claim **10**, wherein the vibration absorber is at least one of a spring and a damper.

12. The electromagnetic relay as claimed in claim **3**, further comprising:

a magnet for magnetic extinction;

a third projection portion for pressing the magnet provided on a rear surface of the upper cover; and

a recess portion for housing the magnet provided on an inner wall of the second cover.

13. The electromagnetic relay as claimed in claim **1**, wherein

the first cover includes a space for prolonging arc discharge which arises in the contact portion at an upper part of a side surface of the first cover, and

a member for cooling the arc discharge is provided on at least one of the inside of the space and a position opposite to the space.

14. An electromagnetic relay, comprising:

a first housing;

an electromagnet enclosed within the first housing and including a first terminal extending toward an outside of the first housing;

a contact enclosed within the first housing, that opens and closes according to a magnetic attractive force of the electromagnet, and has a second terminal extending toward the outside of the first housing;

a printed circuit board to which at least one of the first terminal and the second terminal is soldered;

a second housing in which the first housing and the printed circuit board are enclosed; and

a cable line soldered onto the printed circuit board and extending to an outside of the second housing,

wherein the cable line and at least one of the first terminal and the second terminal soldered onto the printed circuit board are electrically connected through the printed circuit board to each other.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,704,621 B2
APPLICATION NO. : 13/869561
DATED : April 22, 2014
INVENTOR(S) : Hasegawa et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page Item [72] (Inventors), Line 2, delete "**Daiel**" and insert -- **Daiei** --, therefor.

Signed and Sealed this
Twenty-second Day of July, 2014

Michelle K. Lee

Michelle K. Lee
Deputy Director of the United States Patent and Trademark Office